Instruments

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Instrumentation Modernizes Industry and Creates New Industries

I

IN December 1932, industrial production was at a low ebb. Financial and industrial writers drew all kinds of inferences from the November Presidential and Congressional elections, made all kinds of predictions and gave all kinds of advice. After reading what these highly-touted experts wrote, we felt such contempt for their sugary style and for their "Uncle-Sam-will-save-us-all" attitude that we dashed off for this page a non-sugar-coated sermon.

Today, industrial production is spotty—some companies are doing well; others badly. Experts once more lay blame on certain politicians and pin hopes on other politicians. It seems to us that such experts do harm by causing industrialists (executives, engineers, Public Relations staffs, etc.) to waste too much time and effort on Washington lobbies and on nation-wide propaganda and to devote too little time and effort to SELF-HELP.* Perhaps it's in order to reprint that blunt sermon of December 1932. Here it is, only slightly abridged:

Every reader of this magazine pays the butcher, the baker and the instrument-maker with money that comes directly or indirectly from industry—from the profitable conversion of raw materials and raw energy into saleable goods and services.

Some cells in living tissue die shortly after their formation; others thrive indefinitely. So in any industry do some plants starve to death while others grow. Complex and multifarious as is a modern industry, its individual units are subject to the implacable law of existence; feed or die. A starved organism cannot remain alive; a business that makes no profits cannot survive.

Organisms incapable of adapting themselves to changing biological conditions must perish; so must a business cease to exist which does not adapt itself to changing economic and technological conditions.

A new era of competition has begun. Its rigors will not be tempered, its fierceness not allayed, for American industries are not like a herd of bisons that can be saved from starvation by a benevolent government.

Close your ears to wish-inspired rumors of paternalistic panaceas, for THE SOCIALISTIC SANTA CLAUS IS A MYTH. Open your eyes to the grim reality. Adapt your plant to rapidly-changing conditions, so that your business may regain the ability to sustain its own existence by feeding itself—by making profits. In short, modernize!

Modernization is not only a way out: it is the way forward. In the pitiless race for profits those plants are doomed which lag behind; but fortunate are those that rid themselves of outworn methods and arm themselves with modern methods: not only will they eat their fill from the start, but this hearty breakfast will make them abler yet to pursue subsequent meals.

Many and varied are the phases of the modernizing process, but it consists essentially of CONTROLLING ALL VARIABLES. Hence the importance of Instrumentation.

Perhaps the chief value of Instrumentation, at this critical time, is that it permits modernizing at minimum cost. Many a department which hasty judgment condemns to the scrap heap can be saved and made profitable by the judicious installation of measuring and automatic-control instruments. So take heart: leadership may be won by an effort well within your actual power!

II

IN 1932, Instrumentation's part in modernizing industries and creating new industries was recognized only in a few cases. One was the "artificial wood" industry. In our September 1932 issue, W. A. Cotton, Jr., of the Masonite Corporation, gave it full credit in an article entitled "Instruments Help to Build and Sustain a New Industry." This detail-packed article helped make history.

III

IN opening the Pulp and Paper Session of the ISA meeting at Toronto a few weeks ago, Chairman J. N. Franklin uttered an inspiring prophecy which reminded us of Cotton's 1932 article on the Masonite Corporation. Here is what Franklin said:

Yesterday Lee Dougan told you that management was completely sold on the value and need of well-applied Instrumentation. That is true in most of your industries but not necessarily so in the paper industry. Far from it!

There are two major reasons for this, which should be kept in mind as the meeting progresses.

Firstly—The paper industry is an old, rule-of-thumb industry in which values are much more difficult to measure with any degree of accuracy than in our sister industries.

Secondly—Men have just not been available within the engineering and in the maintenance fields in sufficient numbers and sufficiently well qualified to justify extensive instrumentation.

That picture is changing.

Gentlemen, the decade 1940-1949 saw such strides in the growth of petroleum chemistry that today it makes oil a by-product of that great and growing chemical industry.

I firmly believe that you and I stand today on the threshold of another great and similar decade in another great industry. I believe that by 1960 paper as we know it today will have become the by-product of wood chemistry. That change, gentlemen, will be possible only with and by the wise application of Instrumentation.

IV

Turn to page 494 for the latest example of a new industry which Instrumentation did much to create, first in Germany and now (with improvements and refinements) in New Jersey.

And look up the pictorial article in the March issue on the instrumentation of the new coal gasification pilot plant . . . and watch for more such articles . . . and DO YOUR PART!

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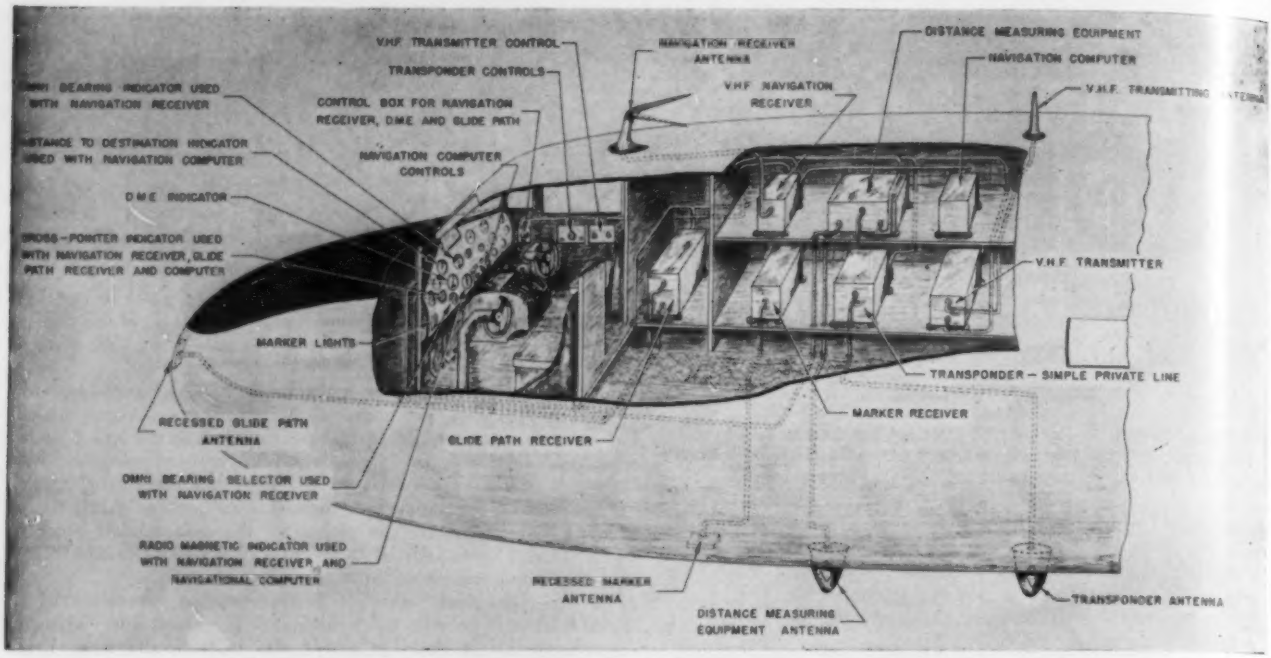
*This does not imply—and readers should not infer—that *Instruments* recedes even partly from its anti-Socialist position as expressed on this page in February and in April.

This does not imply—and readers should not infer—that we no longer urge readers to write IN THEIR OWN WORDS to their Senators and Representatives in opposition to Socialistic laws and directives. On the contrary, we again urge such action by individual citizens.

It is precisely because of our faith in our form of government that we believe in the efficacy of such letters or personal calls by individual citizens, and of letters and calls by officials truly representing voluntary associations of citizens and truly speaking for the great majority of the dues-paying members of such voluntary associations.

It is precisely because of our faith in our form of government that we do not believe in the long-run efficacy of selfish lobbies, of "invisible governments," of propaganda by private interests, of slanted news in the press and on the radio, etc. To be sure, the expenditure of a few million dollars CAN kill pending legislation and cause the opposite to be enacted, but only for a short time in the life of our beloved Nation which is measured in centuries. Moreover, by reason of the law of diminishing returns, it becomes more and more costly to "fool all the people some of the time," whereas, on the other hand, it becomes less and less costly (in terms of unit cost of product) to instrumentize and automatize an industry. Finally, it is unethical to milk a company (or union)—especially when the money goes to propaganda experts whose expertness is not to influence legislation but to scare contributions out of their clients. If the money handed by Industry to such racketeers were invested in automatization . . . ! Don't you share this wish?



Basic airborne equipment requirements, Common System Transition Program.—Short-distance navigation and traffic control. *(CAA photo.)*

Modern Air *and* Ground Instrumentation *in* America's Air Navigation Program

By D. W. RENTZEL, Administrator of Civil Aeronautics, Washington, D. C.

Introduction

CIVIL and military aviation in the United States labor under the intolerable handicap of an inadequate airway and airport traffic control system, which was designed and installed when aviation was in its infancy.

All-weather flying, schedule reliability, and mass movement of aircraft under instrument conditions can be accomplished only if the United States installs an improved, modern air navigation and control system. Such a system no longer is merely desirable; it is an urgent necessity today from both military and civil standpoints.

After years of individual efforts to solve the problem of all-weather flying, every significant branch of military and civil aviation now has agreed on the details of a new air navigation system which will meet the needs of all. Such a system has been approved by the Congressional Aviation Policy Board and the President's Air Policy Commission.

Special Committee 31

In the progress of United States military and civil aviation, two weaknesses have grown glaringly conspicuous as other deficiencies were corrected, one by one. Despite magnificent aircraft and the world's most skilled pilots, air travel schedules are uncertain, and the safety record none too good when compared with other forms of public transportation.

These two weaknesses of present-day aviation are closely related. They center around the problems of bad-weather air navigation in three-dimensional space, where scores of planes must move along the same general path at terrific speed without being able to see each other or see the ground.

Almost every airline passenger has suffered annoyance and inconvenience from weather delays, cancellations, or diversion to some city other than his intended destination. These uncertainties of air travel cost the airlines many millions of dollars annually in direct costs and in loss of potential passenger and cargo traffic.

These weather irregularities are even more serious from the standpoint of National Defense, for in case of a sudden emergency, our military air forces would be equally handicapped in trying to move men and supplies to key points by air.

The Civil Aeronautics Administration, the (then) Army Air Force, and the Navy, each recognizing the need of all-weather reliability, at one time undertook independent research and development programs. There was some justification for separate approaches to the problem of air navigation and control—the needs and emphasis of civil aviation and of the several branches of military aviation are not identical.

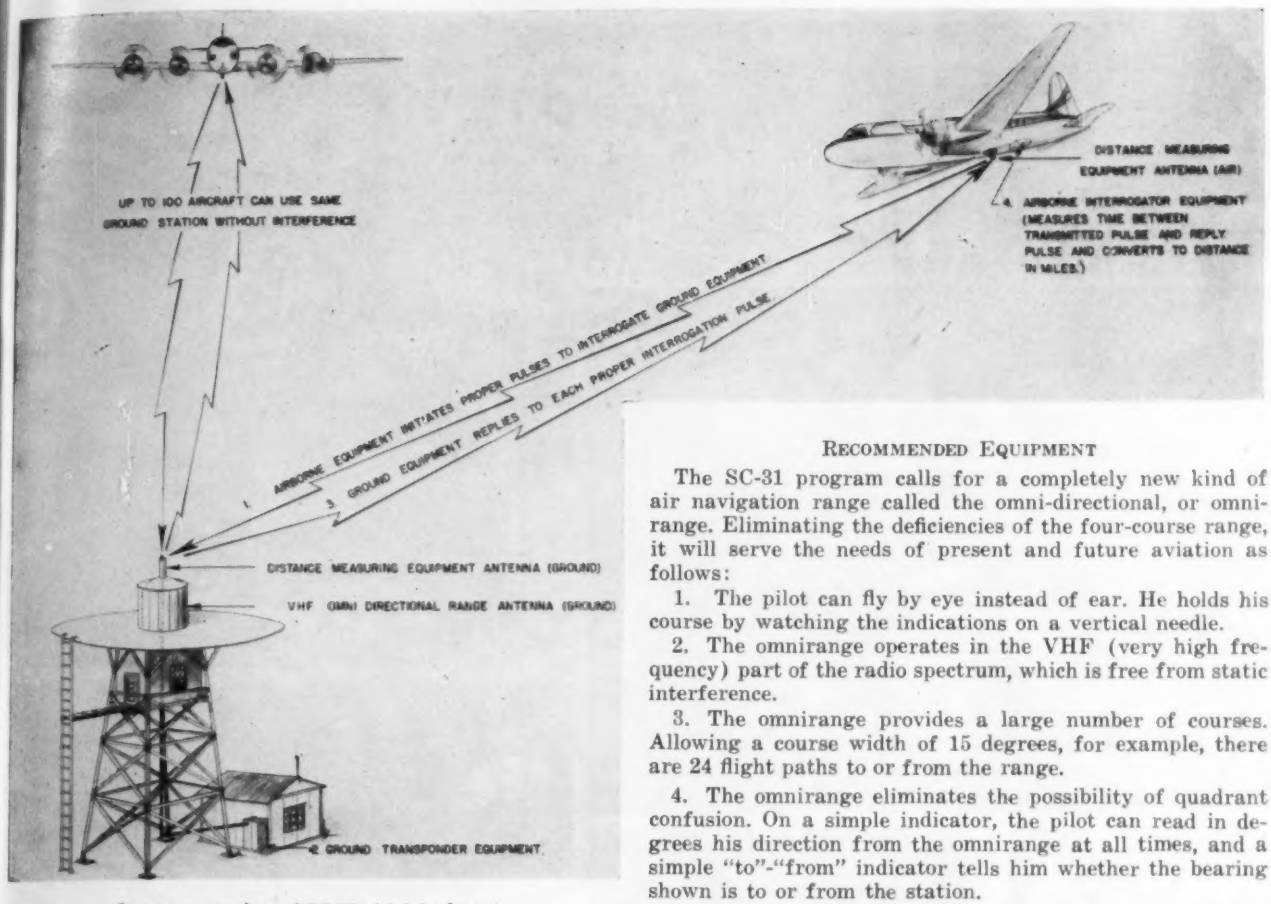
But it was clear that the United States could not afford the luxury—and confusion—of several kinds of airway systems operating simultaneously. Early in 1948, this point was underlined and emphasized in two major documents, the reports of the President's Air Policy Commission and of the Congressional Aviation Policy Board.

Meanwhile, the Air Coordinating Committee* had asked the Radio Technical Commission for Aeronautics** to study the problem of air navigation and try to reach an agreement on what form the air navigation system should take. The RTCA, in turn, appointed Special Committee 31, representing the many aviation interests, to prepare a detailed study for the parent body.

The members and alternates of SC-31 formed a representative cross-section of aviation. Included were Aeronautical Radio, Inc., Air Line Pilots Association, Air Transport Association of America, Aircraft Owners and Pilots Association, Civil Aeronautics Administration, Civil Aeronautics Board, Department of the Air Force, Department of the Navy, Department of State, Department of the Treasury,

*An interdepartmental group appointed by the President which coordinates the policies of the Federal agencies principally interested in the aviation field.

**A government-industry organization concerned with telecommunication matters, and representing almost every public and private aviation group in the United States.


UP TO 100 AIRCRAFT CAN USE SAME GROUND STATION WITHOUT INTERFERENCE
DISTANCE MEASURING EQUIPMENT ANTENNA (AIR)
4. AIRBORNE INTERROGATOR EQUIPMENT (MEASURES TIME BETWEEN TRANSMITTED PULSE AND REPLY PULSE AND CONVERTS TO DISTANCE IN MILES.)
1. AIRBORNE EQUIPMENT INITIATES PROPER PULSES TO INTERROGATE GROUND EQUIPMENT
3. GROUND EQUIPMENT REPLIES TO EACH PROPER INTERROGATION PULSE
DISTANCE MEASURING EQUIPMENT ANTENNA (GROUND)
VHF OMNI DIRECTIONAL RANGE ANTENNA (GROUND)
2. GROUND TRANSPONDER EQUIPMENT

System operation of DME. *(CAA photo.)*

Federal Communications Commission, and Radio Manufacturers' Association.

Special Committee 31 accomplished the difficult and arduous task of reconciling the many viewpoints and bringing all aviation together on a common air navigation program.

The SC-31 report outlined plans for a common air traffic control system, useful equally to the armed services, the scheduled airlines, non-scheduled air carriers, and private fliers. The plan was divided into two parts—a transition program to be completed in about five years, and an ultimate program requiring another ten years.

It was approved by the RTCA early in 1948 and now stands as the "bible" for all future work in the air navigation field by member agencies.

The transition program, of immediate concern, calls for installing many devices already in the development and service-testing stages. Other devices require additional research to be certain that in their final production form they offer maximum reliability and accuracy.

The older air navigation system which has proved inadequate, but still is in general use today, is based on low-frequency four-course radio ranges. These ranges suffer from serious inherent deficiencies:

1. The pilot must listen continuously to a monotonous series of dots and dashes in order to remain on course.

2. The ranges are subject to static interference, which in severe cases can blot the range out altogether.

3. A plane's position on the right or left side of an airway is vague and uncertain, because it depends entirely on the hearing acuity of the individual pilot.

4. Traffic capacity is limited by the fact that there are only four courses or flight paths.

5. To eliminate the possibility of dangerous confusion between quadrants, a pilot must fly a complex, time-consuming orientation pattern.

Recommended Equipment

The SC-31 program calls for a completely new kind of air navigation range called the omni-directional, or omnirange. Eliminating the deficiencies of the four-course range, it will serve the needs of present and future aviation as follows:

1. The pilot can fly by eye instead of ear. He holds his course by watching the indications on a vertical needle.

2. The omnirange operates in the VHF (very high frequency) part of the radio spectrum, which is free from static interference.

3. The omnirange provides a large number of courses. Allowing a course width of 15 degrees, for example, there are 24 flight paths to or from the range.

4. The omnirange eliminates the possibility of quadrant confusion. On a simple indicator, the pilot can read in degrees his direction from the omnirange at all times, and a simple "to"-"from" indicator tells him whether the bearing shown is to or from the station.

On these points alone, the omnirange will contribute substantially to easier, safer, and more reliable air navigation. But under the SC-31 program, two other devices will be combined with the omnirange to produce something close to the optimum in simplicity and flexibility. These devices are the DME (Distance Measuring Equipment) and the Course Line Computer.

The present air navigation system includes radio markers at intervals on the airways to tell the pilot how far he has progressed along his route. They cause a light to blink in the cockpit for a few seconds, and make a characteristic sound in the pilot's earphones.

Since these markers are rather widely spaced, the pilot is certain of his exact position for only a small part of his total flight time. This is a serious deficiency, since the ground traffic control system depends on accurate position reports from the pilot. With the present system, the accuracy of these position reports varies considerably.

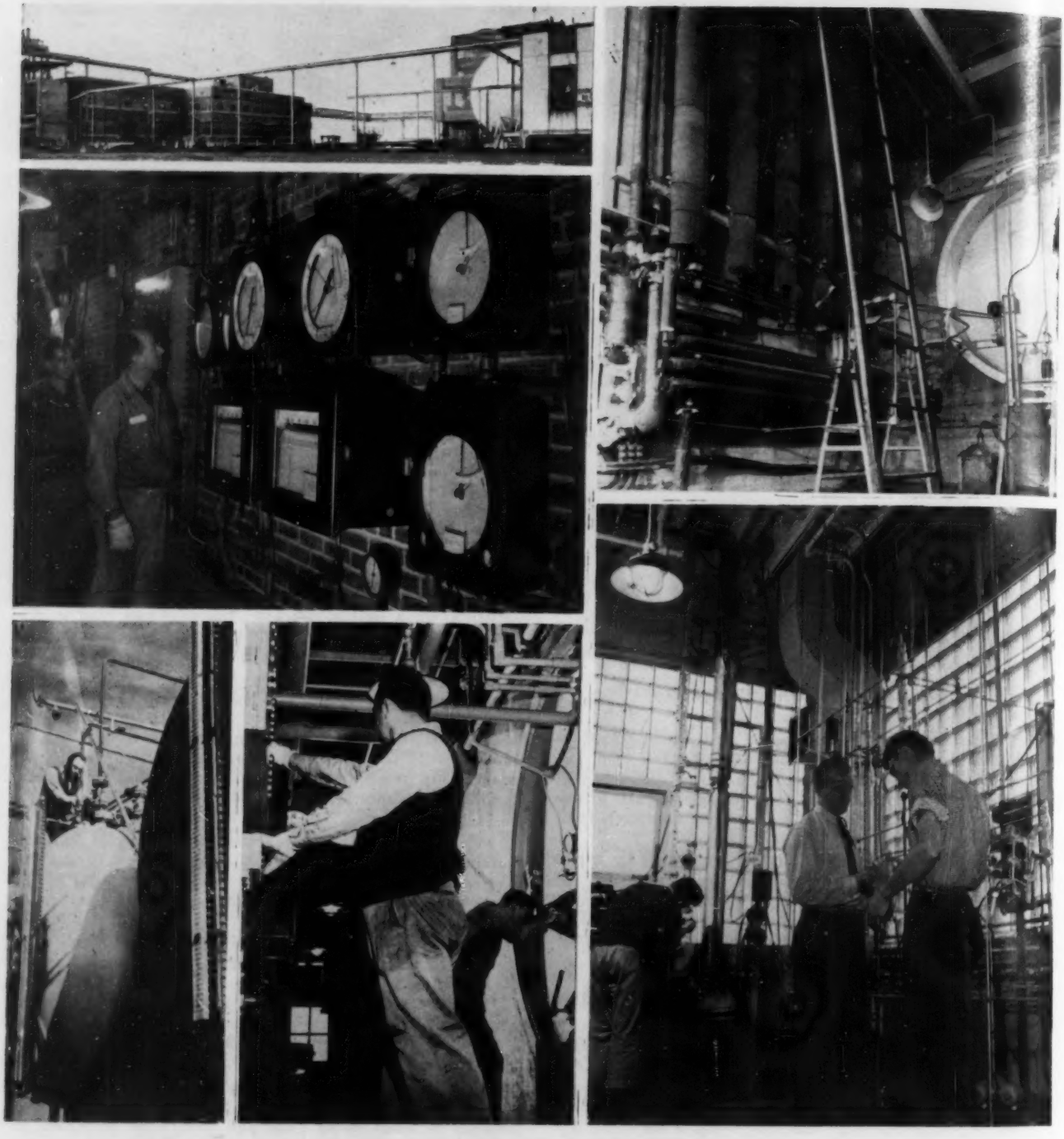
DME equipment, installed at each omnirange, will do away with this uncertainty. In a suitably-equipped plane, the pilot will be able to read on his DME dial the exact distance in miles to or from the omnirange to which he is tuned.

The omnirange indicator, mentioned earlier, plainly shows the pilot the bearing of the range. The DME pointer tells him his distance. The pilot, therefore, will know at all times his exact position in space and can provide the accurate information necessary for ground traffic control.

The course line computer introduces additional flexibility to the omnirange-DME combination. The computer, a lightweight airborne electronic "brain," makes it unnecessary to fly directly to or from an omnirange. Using the computer, DME, and omnirange, a pilot can fly a straight course between any two selected points.

The pilot sets certain information into the computer. Then the computer, using additional data received from nearby omniranges and DME transmitters, continuously solves the

Continued on page 534



First High-pressure Acetylene Plant *in the* United States

ONCE more, Instrumentation makes possible the creation of a new industry. At Grasselli, N. J., on March 21, General Aniline & Film Corp. opened its high-pressure acetylene pilot plant where new and unusual chemical reactions are remotely controlled with perfect safety to the operating personnel. *(Top left)* Panoramic view: From the carbide generators in the building at the right, acetylene is carried overhead to the reaction bays on the left of the main building. *(Left center)* Vinylation equipment control board. *(Bottom left)* Levels of liquids in outdoor tanks are measured and automatically controlled. *(Bottom center)* Heavily-reinforced instrument and control-station corridor with steel-plate sections runs full length of five bays used for reactions. Here all operations in the bays and towers are controlled. *(Top right)* High-pressure hydrogenation towers at left; at right, one of the circular steel plates with peep-holes for direct observations. *(Bottom right)* Control laboratory not only tests products of pilot plant but solves operational problems. In background, a forty-plate distillation column.

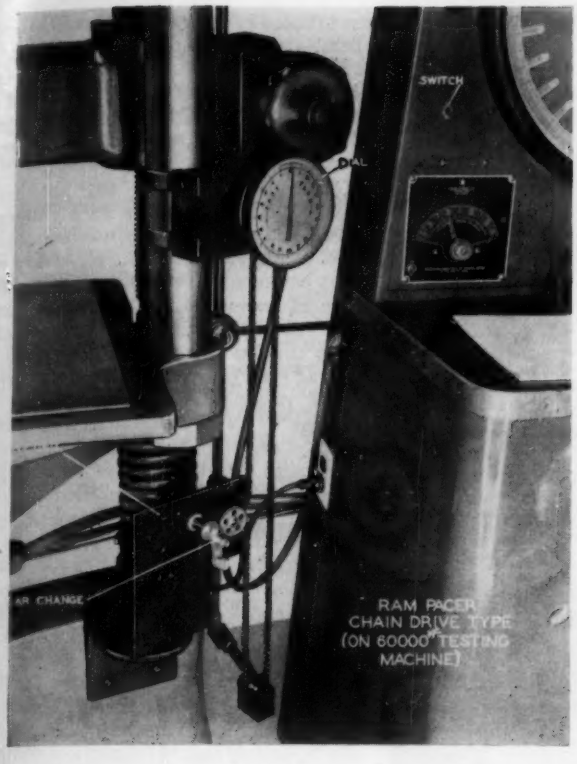


Fig. 1

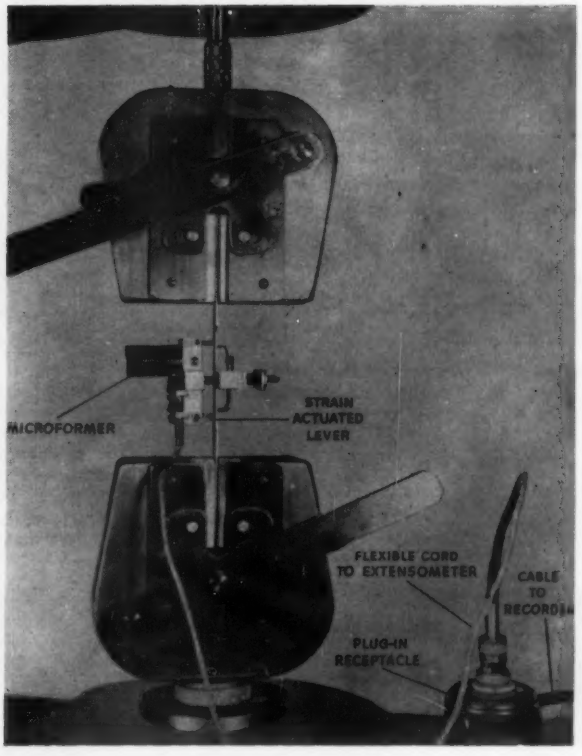


Fig. 2

Methods *of* Speed Control *for* Testing Machines

By LAWRENCE K. HYDE, O. S. Peters Co., Engineers, Washington, D. C.

INSTRUMENTATION of testing machines for closer control of testing speed than was then possible has been given considerable attention since 1946 when the American Society for Testing Materials started to compile information on the capabilities and limitations of the methods then in use for controlling the speed of testing.

Two testing speed control methods are frequently employed on modern types of testing machines. The rate of applying the load is controlled in one method and crosshead speed (or rate of crosshead separation, or ram travel) in the other.

A third method, which is a recent development and hence not yet frequently employed, enables control of the rate of straining in the specimen. It is especially well suited to tension tests, but it is equally adaptable to transverse and compression tests.

Control equipment for all three methods being available from The Baldwin Locomotive Works, the author is using Baldwin photographs for illustrating this article.

First Method—Load Application Rate Control

Most modern testing machines are equipped with a pacing device by which to maintain a predetermined uniform rate of loading a specimen. This pacing device may consist of (1) a disk, hand or pointer that can be rotated by a clockwork or by a synchronous motor at a rate corresponding to the desired uniform rate of applying load, and (2) a load-indicating pointer that can be synchronized with the pacer by adjusting load controls to produce the desired loading rate.

This method of speed control has the advantage of being independent of the type of testing machine or the nature of the test set-up with which it is employed. A uniform rate of applying load means that a fixed number of load units per unit of time are applied to the test specimen whether the testing machine is operated by hydraulic or screw power or other means, and whether the specimen is tested in tension, compression, or flexure. This assures a high degree of reproducibility of tests (up to the proportional limit).

A limitation of this method is that beyond the proportional limit the rate of straining may increase more rapidly than desired. Furthermore, it is not practicable or even possible to maintain a uniform rate of application of load much beyond the proportional limit of many materials. Consequently, testing speed may not be controlled during an important phase of the test, such as through the point on the stress-strain curve that is used in determining yield strength.

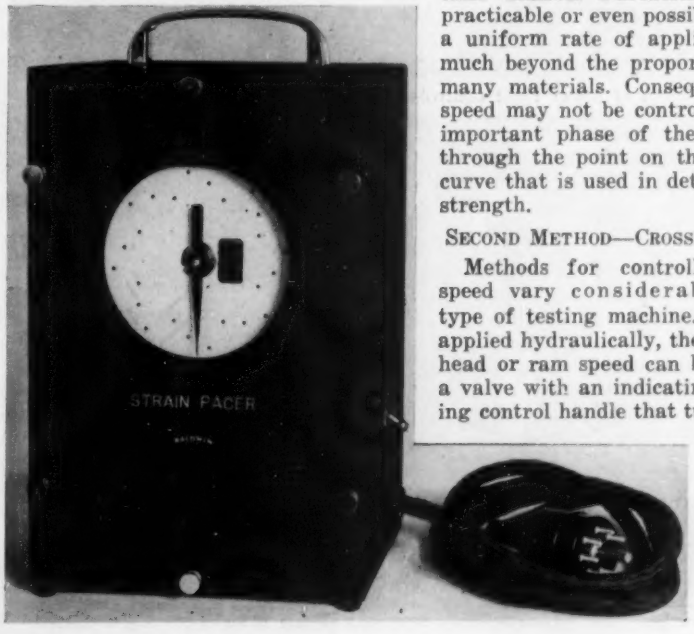


Fig. 3. Strain pacer indicator, in a separate cabinet which may be located conveniently.

Second Method—Crosshead Control

Methods for controlling crosshead speed vary considerably with the type of testing machine. When load is applied hydraulically, the rate of crosshead or ram speed can be adjusted by a valve with an indicating and adjusting control handle that turns on a scale

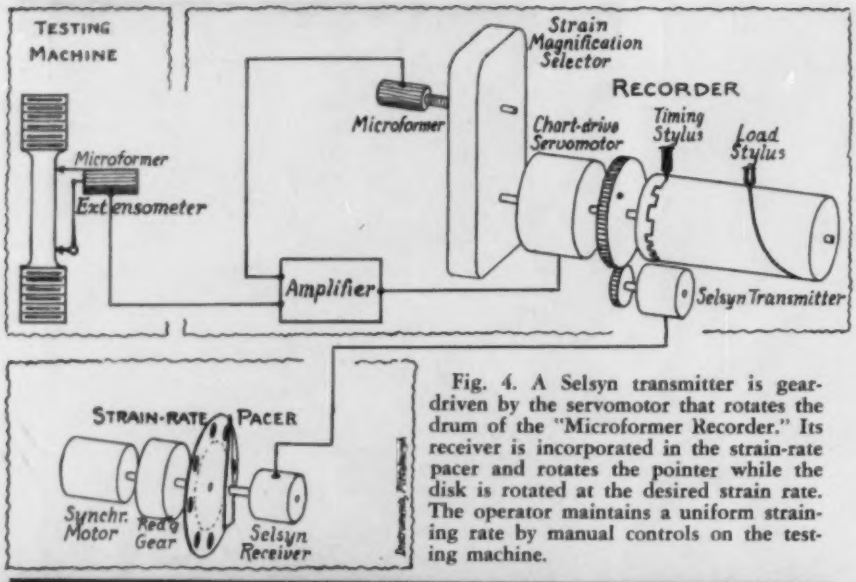


Fig. 4. A Selsyn transmitter is gear-driven by the servomotor that rotates the drum of the "Microformer Recorder." Its receiver is incorporated in the strain-rate pacer and rotates the pointer while the disk is rotated at the desired strain rate. The operator maintains a uniform straining rate by manual controls on the testing machine.

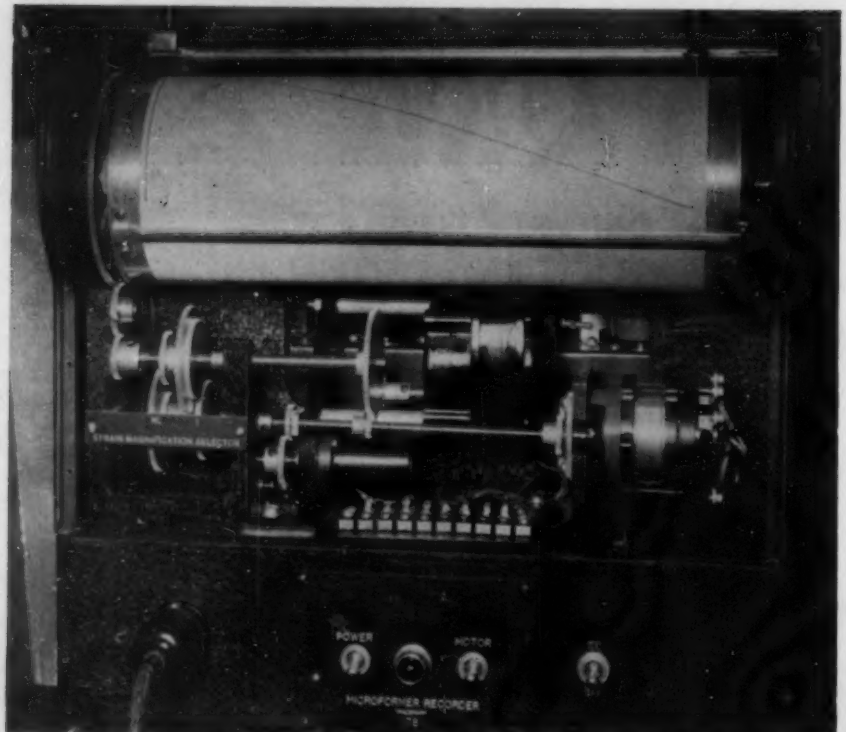


Fig. 5. Selsyn at lower right controls rotation of strain-indicating pointer.

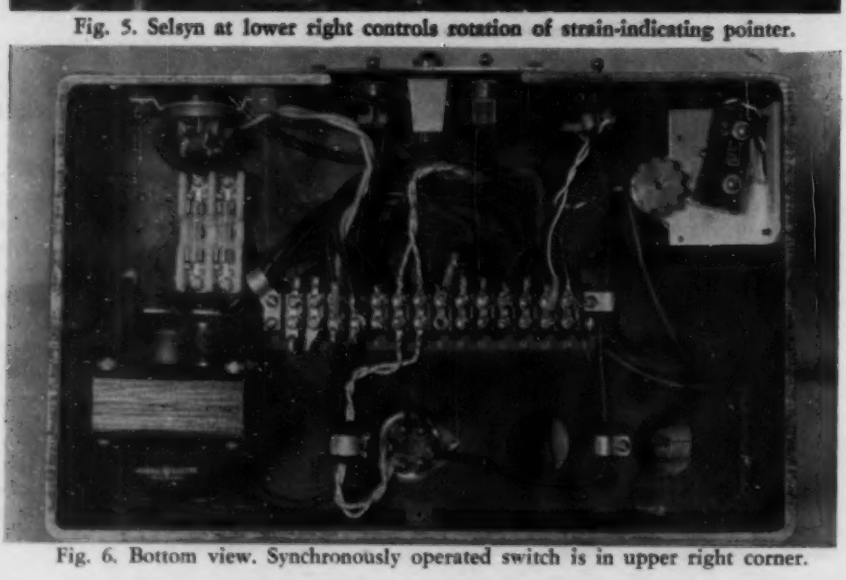


Fig. 6. Bottom view. Synchronously operated switch is in upper right corner.

graduated to indicate the nominal crosshead speed. When load is applied by screw power on modern testing machines, the rate of crosshead speed can be adjusted by a knob on a graduated dial which controls a variable-speed motor.

The uncertainty of the position of manual control devices as an index of crosshead speed has been eliminated by pacing instruments that show the relation between a predetermined uniform rate of crosshead speed and the actual rate at which the test is proceeding. This enables the operator to adjust the actual rate to synchronize with the desired rate. Such pacing devices are similar to those for controlling loading rate except that the pacer indicates crosshead speed instead of loading rate.

Fig. 1 shows an application of a method of controlling crosshead speed announced in 1945. The apparatus, attached to a standard hydraulic testing machine, holds crosshead movement at any of eight pre-set speeds: 0.01, 0.02, 0.05, 0.1, 0.2, 0.4, 0.5 and 1.0 inch per minute. Speeds are varied by gear changes on the synchronous-motor drive unit which is attached to a fixed frame of the machine. The dial, pointer-drive chain, and sprocket frame, are mounted on the moving crosshead.

When the crosshead is stationary the synchronous drive motor rotates the pointer at the pre-set speed. The desired loading speed is produced by opening the hydraulic valve until the speed of the loading head counteracts the chain movement around the pointer sprocket and the pointer is held stationary. The ram pacer can be used as a deflectometer also by locking the drive unit. Each of the 200 graduations on the dial indicate 0.001 in. crosshead movement.

This method has the advantage of providing reasonably easy control of crosshead speed throughout the elastic and plastic deformation ranges of the test specimen, but it has several shortcomings:

First, the rate of straining in the specimen, especially in tension tests, may vary considerably, depending upon the type of test set-up and the type of testing machine.

Second, the rate of straining in the specimen is not uniform. It increases as the load increases, increasing rapidly during the transition from the elastic to the plastic range of the specimen.

Third, since only a small fraction of the crosshead travel appears as strain in the specimen during a tension test, reproducibility of this test, even in the same testing machine, depends on such factors as specimen grips or holders and the length of test specimen.

Fourth, differences in testing machine construction are factors in reproducibility of test conditions as related to straining rate in the specimen when tests are conducted under controlled rates of crosshead speed. For example, when the weighing crosshead is fastened to the frame of the testing machine, the speed of the moving crosshead relative to the frame is also a

measure of the rate of separation of the two crossheads, whereas when the weighing crosshead has appreciable movement relative to the frame of the testing machine, the speed of the moving crosshead relative to the frame of the testing machine is not an accurate measure of the rate of separation of the two crossheads. This can have an adverse effect on reproducibility of tests when they are made on different types of testing machines.

Third Method—Strain Pacing

It is now possible for an operator of a testing machine to maintain a uniform straining rate through the elastic range and as far into the plastic deformation range of the test specimen as desired. An extensometer directly mounted on the specimen (see Fig. 2) converts a mechanical displacement (strain) into a voltage, permitting a magnified reading of strain at a distance. Most effective utilization of this method requires autographic stress-strain recorder equipment.

The principle and application of strain pacing are similar to that of the load and crosshead pacing devices previously described. The strain rate pacer, shown in Fig. 3, includes a pointer that follows the strain in the specimen and hence rotates at a rate proportional to the strain in the specimen. A dotted disk, coaxial with the pointer, rotates at a predetermined uniform rate. The strain pacer indicator shown in Fig. 3 is in a separate cabinet which may be located conveniently for the operator.

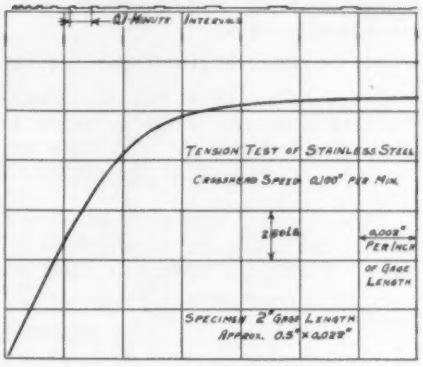


Fig. 7

A uniform straining rate is maintained by the operator by controlling the speed of the testing machine so that the pointer rotates at the same speed as the disk. The pointer of the strain rate pacer, which is under the control of the extensometer on the test specimen, is rotated by a self-synchronous motor that receives its energy from a self-synchronous generator or transmitter. This transmitting generator is shown in Fig. 5 at lower right. It is driven by the same servomotor that rotates the chart drum. The pacing indicator is electrically connected with the transmitter, and with the power source for its constant-speed disk, by a polar plug. Disk speed can be varied by several gear combinations in the indicator case. Strain magnification can be varied by several gear combinations in the recorder cabinet.

Strain rate pacing offers an opportunity to develop reproducible testing procedure in which testing speed applies directly to the specimen rather than to some function of the machine in which it is tested. This method makes it possible to study the effect of the rate of straining on properties of materials, within the limits of accuracy of the stress-strain recording equipment. It also permits control of testing speed in routine tests of materials that have shown speed effects.

Strain-rate Recording

So far as is known, the speed of testing has not been recorded in the past. In response to growing concern over closer control of testing speed, a simple time-interval marking device has been developed. The stylus of this device records elapsed time in fractional minute intervals on the margin of the stress-strain chart while the curve is being drawn, as shown in Fig 5, thus enabling determination of testing speed in terms of units of load and/or strain per unit of time. The stylus is activated at periodic intervals by a small electromagnet that produces small deflections in the trace made by the stylus. Fig. 6 shows the synchronously-operated switch that energizes the stylus magnet. The timing device gives a permanent record of testing speed and may also be used to check the variations in strain rate that may occur during recorded tests. Fig. 7 shows a tracing of a typical record with autographed time-interval marks.

A RAPID AUTOMATIC METHOD *of* COMPUTING INFRARED SPECTRA *for* QUANTITATIVE ANALYSES

By ROBERT W. FOREMAN and WARREN JACKSON, JR.,
Chemical and Physical Research Division, The Standard Oil Company (Ohio), Cleveland, Ohio.

INFRARED absorption data are conventionally expressed in terms of percentage transmission of infrared radiation through the sample over a specified range of wave-lengths. With the single-beam type of recording infrared spectrophotometer, it is the usual practice to record the transmission curve for an empty blank cell and then record the curve for a cell filled with sample over the same range of wave-lengths. The ratio of the transmission through the sample cell to that through the blank cell times 100 is the percent transmission through the sample alone. In order to express absorption obtained in this way, in terms of percentage transmission, it is necessary to calculate the value of the ratio at each wave length for which a percentage transmission value is desired.

A period of approximately two hours is necessary to record the blank-cell and sample-cell absorption curves over the range of wave-lengths between 2 and 15 microns, using a Beckman Model IR-2 spectrophotometer. An additional four to five hours is required for one person to calculate percentage transmission values from these curves for an adequate absorption spectrum from 2 to 15 microns. This point-by-point computation of ratios is a tedious and slow procedure.

Fuoss and Mead have described* an electrical computer capable of producing percentage transmission curves from the other two curves without requiring point-by-point computation. Their device however, requires considerable ambidexterity for operation, in that the blank and sample curves must be followed simultaneously by pointers while the recorder chart is in motion. Simplification of this computer would be highly desirable. In a footnote to the "laboratory and shop note" of Fuoss and Mead, one of the referees to whom this note had been submitted made a suggestion as to how a simplification could be made which would obviate the need of manually tracing two curves simultaneously. The computer described in this article is a development based upon the suggestion in the above-mentioned footnote.

A considerably simplified instrument has been developed which enables the potentiometer-recorder to plot percentage transmission of a sample while it is being examined by the spectrophotometer for the first time. The ratio of sample-cell transmission to blank-cell transmission is automatically computed by the recorder when a single manually-operated pointer is made to trace the blank-cell transmission curve on the recorder chart while the sample record is being obtained. This results in a saving of four to five man-hours per sample analyzed.

*R. M. Fuoss and D. J. Mead, "Computer for Infrared Spectra," in Laboratory and Shop Notes department of *The Review of Scientific Instruments*, Vol. 16, August 1945, page 223.

APPARATUS

Fig. 1 illustrates an elementary circuit of a continuous-balance recording potentiometer (Brown Instrument Company). In Fig. 1, E_1 is an emf. applied to the recording potentiometer. This emf. is normally adjusted to correspond to the output voltage of the spectrophotometer at 100 percent transmission

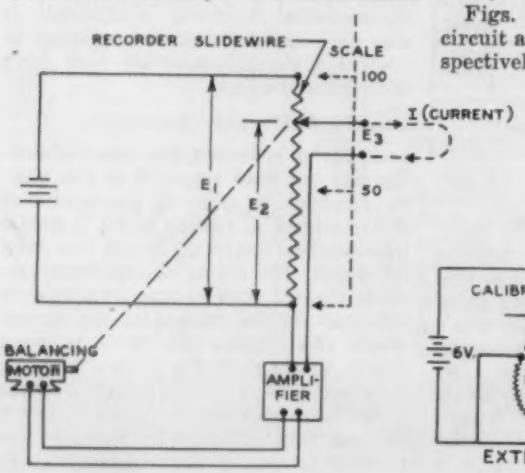


Fig. 1. Circuit of potentiometer recorder.

for a given wave-length and slit width. The emf. output of the spectrophotometer at any percent transmission is E_3. Since the recording potentiometer is automatically in balance with the output of the spectrophotometer and the recording scale is calibrated 0-100, the pen actually records $(E_3/E_1) \times 100$, which is the percent transmission through the spectrophotometer optical system.

The recorded value of the percent transmission of the blank cell at a given slit width and wave-length may be designated as

$$(E_{3(B)}/E_1) \times 100 \quad \ldots \quad (1)$$

The recorded value of a cell filled with sample, under the same conditions of slit width and wave-length is

$$(E_{3(S)}/E_1) \times 100 \quad \ldots \quad (2)$$

The required ratio for the percent transmission of the sample alone at these conditions is

$$(E_{3(S)}/E_{3(B)}) \times 100 \quad \ldots \quad (3)$$

It follows therefore, that if in Equation (2), E_1 can be made equal to $E_{3(B)}$ the recorder pen will trace the percent transmission of the sample directly.

Figs. 2 and 3 illustrate the electric circuit and mechanical arrangement respectively, for the apparatus which accomplishes this purpose. The apparatus consists essentially of a manually-operated variable voltage supply. The proper voltage to be applied is governed by means of the position of a pointer which slides along the glass tear-off strip in front of the recording chart. The position of the pointer is controlled by a knob which is also geared to the shaft of a circular precision voltage-dividing resistor. The pointer is moved by a pully and cord drive. The driving pulley is mounted on the same shaft with the precision resistor and is accurately machined so that the resistor will rotate through its entire electrical range as the pointer moves from 0 to 100 on the recorder scale.

If, when a cell containing sample is in the optical beam of the spectrophotometer, the pointer is manipulated to follow the curve previously recorded for a blank cell, the recording pen will trace a curve which is the percent transmission of the sample. In other words, the value of the ratio $E_{3(S)}/E_{3(B)}$ times 100 is recorded over the range of wave-lengths covered by the tracing.

The electric circuit of the computer, as shown in Fig. 2, is very simple. It consists of a 20-ohm precision resistor (type used in conventional electrical recorders), a small 20-ohm rheostat, a 1000-ohm fixed resistor and four 1.5-volt dry cells. The precision resistor

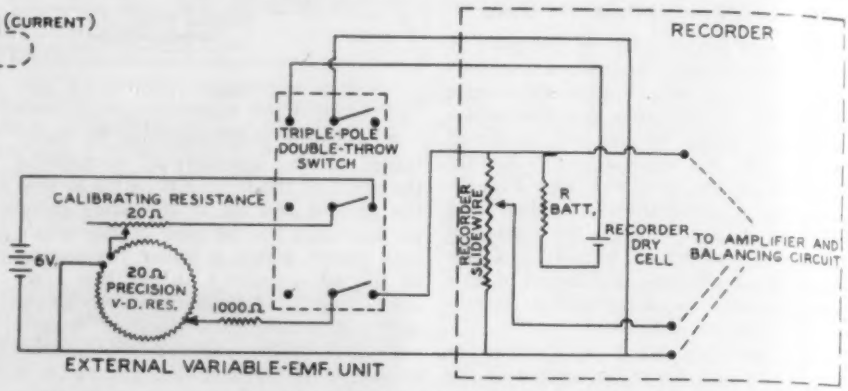


Fig. 2. Circuit of computing recorder.

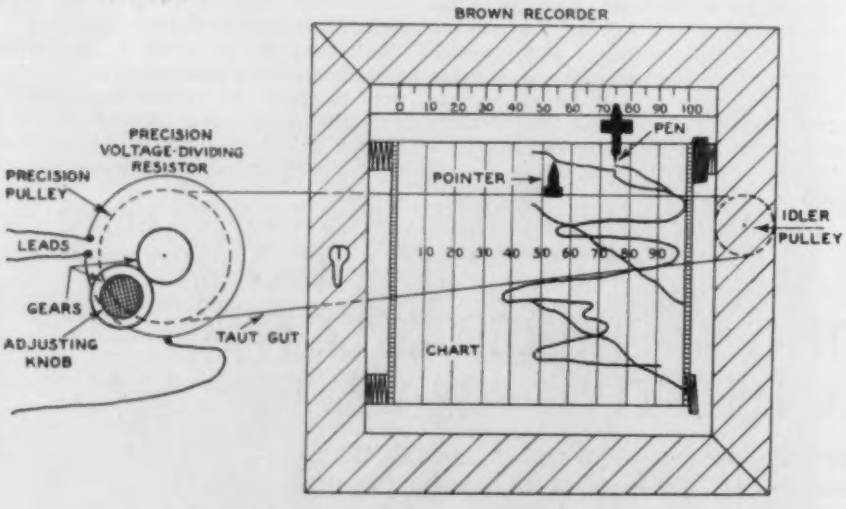


Fig. 3. Mechanical diagram of computing recorder.

acts merely as a voltage divider and its total voltage is adjusted so that, when the pointer is set at 100 on the chart scale, the pen will record the same percent transmission as that indicated by the spectrophotometer dial. The triple-pole-double-throw switch permits the computer to be cut in or out of the recorder circuit as desired. When this switch is engaged to the right, as shown in Fig. 2, the variable emf. of the computer replaces the constant emf. of the recorder battery. When it is engaged to the left, the computer is completely out of the circuit and the recorder operates in the normal manner.

OPERATION

A description of the procedure required to record a portion of the spectrum will suffice to illustrate the operation of the computer:

1. With the blank cell in the light path, initial wave-length and slit-width settings are chosen and the amplifier gain adjusted to give a reading of 100 percent transmission.

2. The triple-pole-double-throw switch is thrown to the left (Fig. 2), or normal, position. The recorder and wave-length drives are started simultaneously. (It has been found that starting the wave-length drive at values previous to those to be recorded and then turning on the recorder as the desired starting wave-length is reached, gives the best results).

3. The recording of the blank is allowed to proceed until the percent transmission has decreased to approximately 50 percent.

4. The wave-length drive is disengaged and reset at the original value. The spectrophotometer is checked by means of the null indicator for instrument drift, which should be negligible. (Normally less than 1 percent).

5. The recorder chart is rolled back to a wave-length position slightly outside of the range to be recorded. A recorder pen containing ink of a different color from that used to record the blank is substituted. The manually-operated pointer is adjusted to the "100" position on the recorder chart scale and the t-p.d-t. switch is thrown to the right, or "COMPUTE" position. The calibrating rheostat (Fig. 2) is adjusted until the recorder pen also indicates "100" on the chart scale. The pen should now give the same reading for either position of the switch.

6. With the t-p.d-t. switch to the right and the sample cell in the light path, the recorder is started simultaneously with the wave-length drive at the same position on the chart as that at which the blank curve was started.

7. The blank cell tracing is followed closely with the pointer by manual operation of the adjusting knob (Fig. 3). The recording pen automatically traces the percent transmission of the sample.

REPRODUCIBILITY AND ACCURACY

The accuracy of the computer may be checked by balancing the spectrophotometer at any setting of percent transmission and by adjusting the pointer to any value on the recorder chart scale greater than the percent transmission. The recorder pen will travel to indicate the value of the ratio of the spectrophotometer percent transmission to the pointer setting. The value indicated by the recorder pen will check the calculated value within plus-or-minus 0.5 percent transmission.

Fig. 4 is a copy of an actual spectrum recorded by the computer and also calculated by the conventional method between 8.1 and 9.4 microns. The calculated points are represented by crossed lines. It may be seen that the two curves coincide almost perfectly.

Surprisingly little dexterity is required to follow the blank cell tracing with the pointer. The same percent transmission curve for a sample may be recorded twice on the same chart by two different operators as a check of the reproducibility of the computer. Fig. 5 is a portion of an actual spectrum which has been retraced by two different operators.

Fig. 6 is a photograph of the computer installed on a Brown recorder used in conjunction with a Beckman IR-2 spectrophotometer. This computer has been in daily service for more than ten months. Its performance has not varied since the time of installation. The percent transmission curves produced by it have proved to be sufficiently reproducible for quantitative analysis. The only maintenance that has been required has been the replacement of the dry-cell batteries.

Acknowledgment.—The authors wish to thank Dr. A. L. Jones for assistance in writing this article, and M. M. Fink and G. W. Nichols for fabrication of the computer.

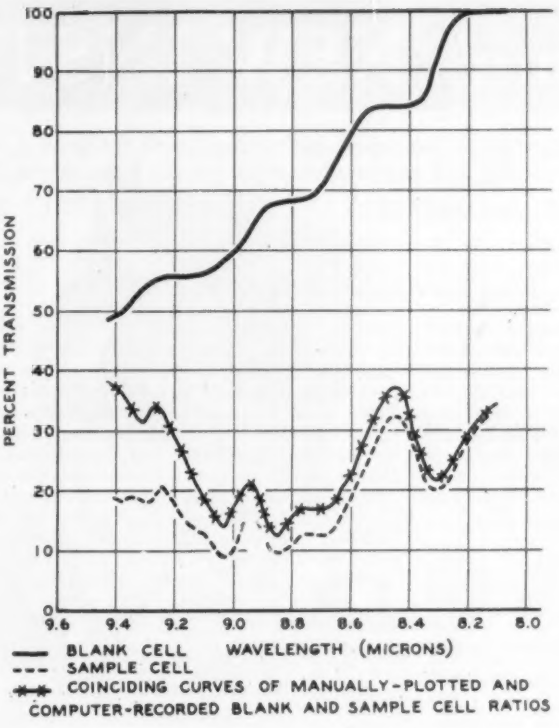


Fig. 4. Spectrum of a cutting oil.

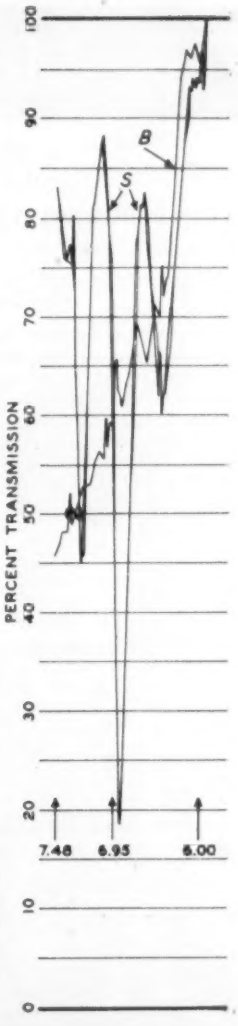


Fig. 5. Exact pantograph trace from a photograph of a portion of the recorded infrared absorption spectrum (6.0 to 7.5 microns) of a hydrocarbon mixture. Curve "B" is that recorded for the blank cell. Curve "S" is the percent transmission of the sample as produced by the computer. In order to demonstrate its reproducibility, curve "S" is actually two curves made by different operators.

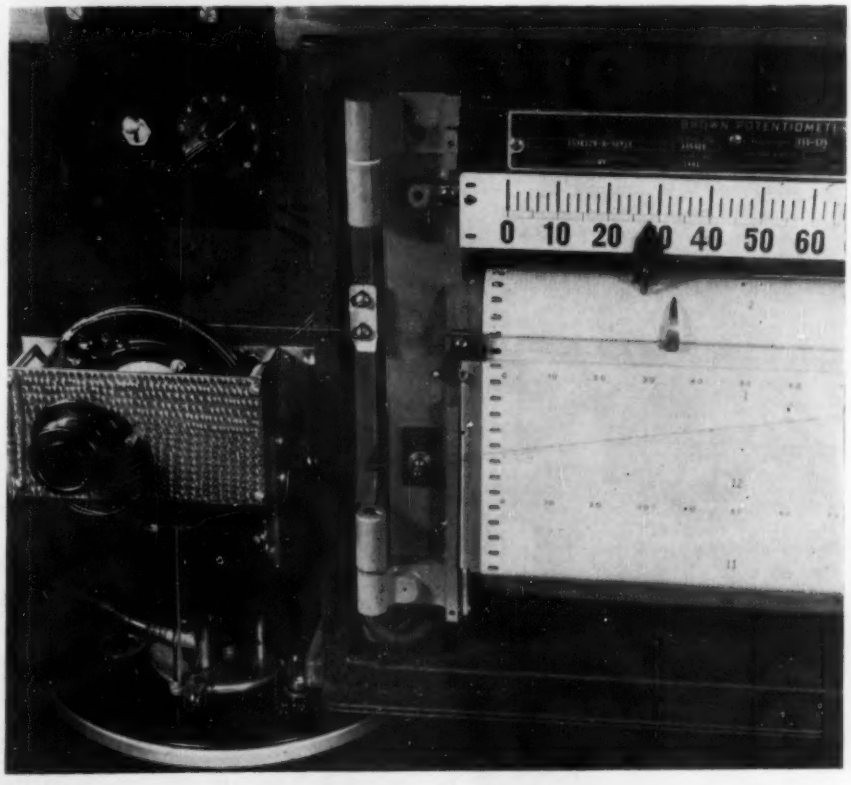


Fig. 6. Computer installation.

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 547

High-precision Instrument Transformers

New "Type JKM-3" line of instrument transformers represents first successful application of butyl-molding technique said to "revolutionize the design and manufacture of instrument transformers." After coil, core and terminals are positioned in a mold, a newly-developed butyl compound is hot-injected under high pressure into spaces around these components, permanently positioning them. This insulation is homogeneous and resilient; resists oxidation, moisture and arcing. Both primary and secondary coils are shaped like figure 8's for mechanical strength and high accuracy. Coil construction and intimate contact of butyl with windings maximize heat dissipation to permit continuous operation up to 150 percent of rated load. Fig. 1 shows ratio and phase-angle characteristics of 5000-volt 10- to 800-amp. models, normal current range, 60 cps. Core is formed of high-permeability steel strips interleaved for mechanical stability and improved accuracy. Strips are held rigidly in place by a steel band welded to steel-plate base. This interleaved-core construction precludes possibility of impairment of accuracy by mechanical shock (short circuits or careless handling). Primary terminals, silver-plated to reduce contact resistance, each have one bolt-hole and a slot to facilitate connection to various-size cable lugs. Secondary terminals are of solderless clamp type. Transparent plastic terminal cover (see Fig. 2) is so built that it cannot be put in place when short-circuit switch is closed and instruments or meters are connected. Dimensions of "JKM-3" are such that it is interchangeable with other transformers. First models available are for indoor metering and relay services, with single primary in all preferred ratings.—*Meter and Instrument Div., General Electric Co., 40 Federal St., West Lynn 3, Mass.*

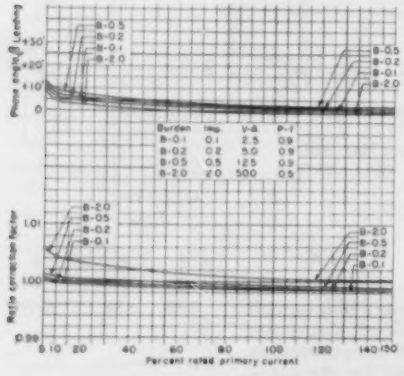


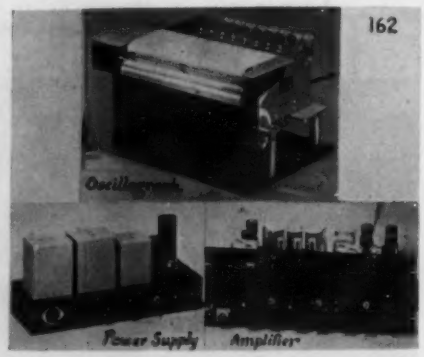
Fig. 1

Fig. 2

Mention No. 601 when filling out card

Pen-writing Oscillograph Assembly

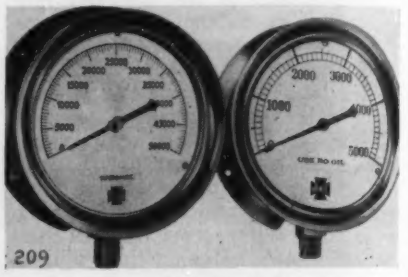
New "Dynograph" is a direct ink-writing oscillograph claimed to have "very high accuracy." With maker's "Type 133" amplifier, it may be used directly with strain gages; seismic pick-ups, reluctance pick-ups, thermocouples, tachometers, etc. A feature of particular convenience with reluctance pick-ups is that no exciting oscillator, rectifier or discriminator is required. From a d-c. source, such as a strain gage bridge, sensitivity of approx. 150 microvolts per cm. is obtained with absolute stability—no base-line drift. Even higher sensitivities are possible with low-resistance sources such as thermocouples. Response time of "Dynograph" pen is less than 0.01 second. Pen is critically damped. Linearity of recorder is one percent for a total pen deflection of four centimeters; maximum deflection is more than seven centimeters. Paper drive is six-speed, synchronous-motor powered. "Type 133" is a three-channel amplifier. Each channel includes a precision step input attenuator, as well as a continuous amplification control. Input panel for each channel allows suitable connection for sources of varying types: balanced or unbalanced inputs, d-c. or reluctance bridges and varying input impedances. Several "Type 133" amplifiers may be used with a single "Dynograph" assembly for any number of recording channels desired. Amplifier is operated from maker's "Type 333" a-c. power supply. Illustration shows an eight-element "Dynograph" and associated units. — *Offner Electronics Inc., 5320 N. Kedzie Ave., Chicago 25, Ill.*



Mention No. 602 when filling out card

High-pressure Gage

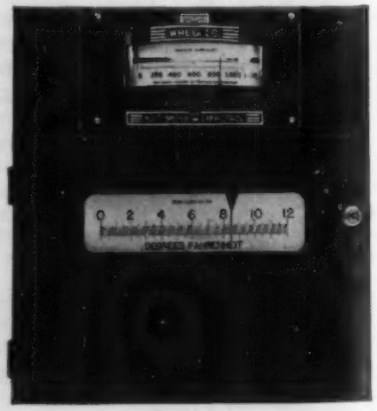
New high-pressure gage has a solid wall, cast integral with case, which separates Bourdon tube and movement section from observer, and entire back of case is fitted with a spring mounted safety release. Safety release plate on back of gage will momentarily discharge high pressure media away from observer. Bourdon tubes are made of beryllium copper or stainless steel and are threaded at both ends with specially cut full threads for interference fit. Gages have deep-bushed stainless-steel geared movements of high ratio. Accuracy is 1 percent of full scale reading up to 50,000 lbs. and 2 percent above 60,000 lbs.—*United States Gauge, Div. of American Machine and Metals, Inc., Sellersville, Penna.*



Mention No. 603 when filling out card

Multi-switch Controller

New "Multi-Switch Capacitrol" indicating controller incorporates such features as a "distant view scale," front



accessibility, plug-in chassis design and voltage selector plug. It is available with a maximum of four switches (s-p.d-t.) to provide a selection of six different switching sequences for a large variety of control functions. A high-resistance fully-compensated direct-reading movement with "Alnico V" magnet is used for applications which fall in pyrometric range. Models using resistance thermometer measuring systems are available for low temperature operation. — *Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.*

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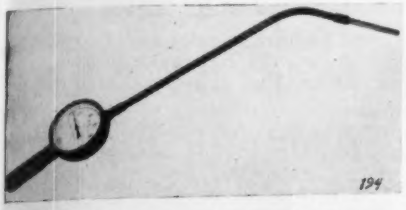
Dial-type Immersion Thermometer

New thermometer has stainless-steel cylinder .5 to 9 in. long enclosing temperature-sensitive element. It mounts at



end of 30-in. steel tube leading to dial head which mounts a pointer that travels through 240 deg. over a 4-in. scale. Thermometer is gas-filled and is claimed to be independent of change in ambient temperatures. A wood handle completes assembly, and all instruments are made to conveniently hang by eye hook on handle. Standard ranges provide maximum readings at 400 to 1,500 F.—*Electric P. & V. R. Co., 1419 Morse Ave., Chicago 26, Ill.*

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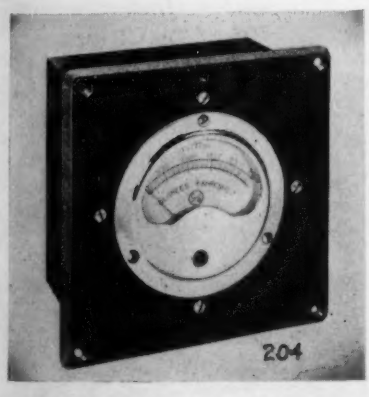
Thermocouple Indicator

New "Model XA 100 Xactemp" high-temperature indicator for general non-critical use is said to be accurate with-



in a fraction of a scale division. Calibrated for either iron-Constantan or Chromel-Alumel thermocouples, a choice of several scale ranges is available. "Xactemp" indicator is furnished enclosed in a metal case suitable for either flush or surface mounting. A plug-in type of lead-wire connection provides easy handling.—*Claud S. Gordon Co., 3000 S. Wallace St., Chicago 16, Ill.*

Mention No. 606 when filling out card

Kelvin-Wheatstone Bridge

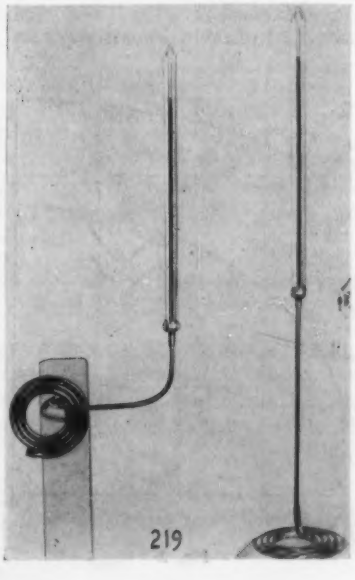
New "Type 638-2-4" Kelvin-Wheatstone bridge combines both bridges in a single instrument and provides Kelvin range accuracy not previously available in former types. Kelvin range is from 0.0001 to 11.11 ohms and Wheatstone

range is from 0.1 to 11,110,000 ohms. Measuring accuracy is plus or minus 0.3 percent for values between 1 and 100,000 ohms and plus or minus 2 percent for values above and below this range. Rheostat arm resistors are adjusted within plus or minus 1 percent for values of 0.1 ohm; plus or minus 0.25 percent for values of 1 ohm; and plus or minus 0.1 percent for all values above 1 ohm. Instrument has a four-decade rheostat arm, a multiplier switch giving ratio multipliers for Wheatstone and Kelvin ranges; battery switches; a built-in galvanometer having sensitivity of 1.0 microamp. per mm. division, and two switches for high and low galvanometer sensitivity. — *Shallcross Mfg. Co., Collingdale, Penna.*

Mention No. 607 when filling out card

Metal-bulb and Glass-tube Thermometer

New glass-tube type refrigeration thermometer has a flexible copper connecting tube running to temperature-responsive bulb. Flexible connection permits installation in a wide variety of places without risk of breaking tube in installation or because of shifting compartments or panels. Thermometer has a large-diameter capillary bore that eliminates need for magnifying red-liquid filling. A well at top of capillary protects thermometer from damage through over-

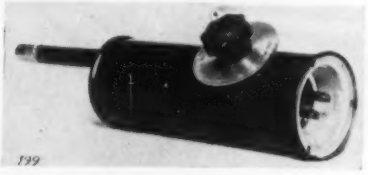


temperatures. Thermometer is available in various ranges from minus 50 to plus 300 F., is furnished without a scale so that it can be matched with user's unit. Ranges may be calibrated to match predetermined scale lengths. —*United States Gauge Div. of Am. Machine & Metals, Inc., Sellersville, Penna.*

Mention No. 608 when filling out card

Adjustable Vacuum-pressure Leak

New vacuum control accessory is based upon Bachman Pulsed Leak principle and is continuously adjustable over



range from completely closed to completely open. It cannot plug up with dust or moisture and may be used with any gas. It may be used alone to give a desired vacuum by balancing leak rate against pump rate or it may be used with maker's vacuum relay monitor to maintain desired degree of vacuum regardless of varying conditions within vacuum system.—*Skaneateles Mfg. Co., Inc., 122 Dickerson St., Syracuse 2, N.Y.*

Mention No. 609 when filling out card

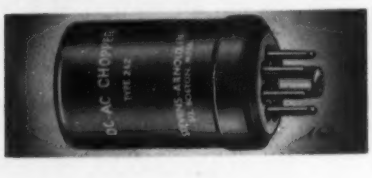
Testing Thermometers

Two new testing thermometers meet specifications of API Code (25 and ASTM 58F-48T and 59S-48T). Although they are specifically designed for measuring, sampling and testing crude oil, they are useful as general test thermometers. New 16.75 in. cup case thermometers (ASTM 58F-48T and 59F-48T) are manufactured in 2 ranges; minus 30 to plus 120 F. and 0 to 180 F. with a guaranteed accuracy of plus or minus 0.5 F. Maker's "Binoc" tubing, large figures and clearly marked one-deg. scale divisions make extremely easy reading. Case is made of oak treated to resist warping. Non-sparking 100-cc. brass cup holds sufficient sample at proper immersion of thermometer tube to maintain temperature while sampling is made. Also offered are new armored thermometers 12 in. long with "Binoc" etched stem thermometer encased in non-sparking brass armor. Ranges: minus 30 to plus 120 F. and 0 to 180 F. (ASTM 58F-48T and 59F-48T).—*Taylor Instrument Companies, Rochester 1, New York.*

Mention No. 610 when filling out card

60-cycle Chopper

New a-c., d-c. chopper converts d.c. into a.c. or pulsating d.c. for use with thermocouples, strain gages, etc., extends maker's line by providing chopper particularly suited for use in range

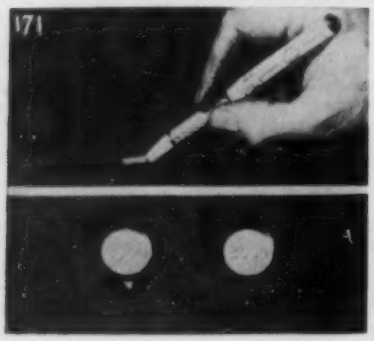


of 45-65 cps. Previous models covering 10-500-cps. range could not incorporate new features of liquid-filling, special shielding and make-before-break contacts.—*Stevens-Arnold, Inc.*, 22 *Elkins St., South Boston* 27, *Mass.*

Mention No. 611 when filling out card

Thermoscopic Crayons and Pellets

New ratings of thermoscopic products are announced in range between 1600 F. and 2000 F. With these additions,

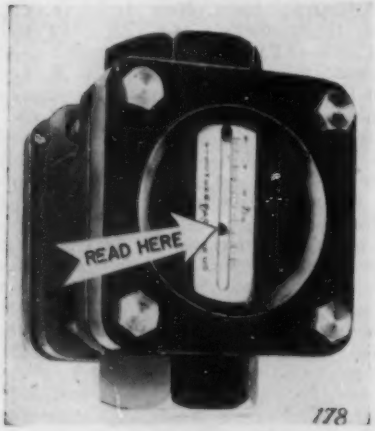


"Tempilstiks" and "Tempil Pellets" are available in 12.5-degree steps from 113 F. to 400 F. and in 50-degree steps from 400 F. to 2000 F.—*Tempil Corp.*, 132 *W. 22nd St., New York* 11, *N. Y.*

Mention No. 612 when filling out card

Flow Guide

New "Magna-Sight" rate-of-flow indicator, equally useful for clear and opaque streams, is adaptation of area

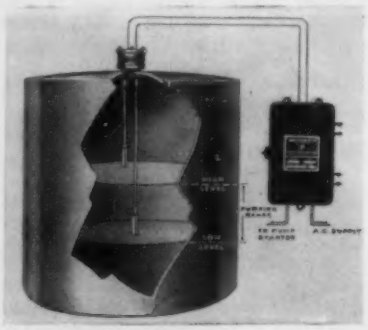


principle of flow measurement. New guide uses maker's standard body with a fixed diameter orifice at its vertical inlet. A tapered plug is suspended in fluid stream within orifice. A permanent magnet imbedded in tapered plug causes an external steel ball to move against a calibrated flow scale when increasing flow rate causes plug to rise. Rear enclosure is a heavy "Herculite" glass window which permits visual observation of fluid. "Magna-Sight" measures maximum flow rates of 3.5 to 250 gpm. Minimum measurable flow rate for any indicator is 0.1 of maximum.—*Fischer & Porter Co., Hatboro, Penna.*

Mention No. 613 when filling out card

Liquid-level Controller

New "Series 10" liquid-level controller, for all liquids that conduct electricity such as acids, salts, milk, beer,



etc., has probe circuit that can be set at different sensitivities. Maker claims that it will differentiate between liquid itself and saturated air above liquid or foam. Two probes are placed in tank at different levels to start and stop flow to keep volume within desired limits.—*—Photoswitch, Inc.*, 77 *Broadway, Cambridge* 42, *Mass.*

Mention No. 614 when filling out card

Leak-detector Sampling Probe

New "Type 18863" sampling probe is used with maker's mass-spectrometer-principle (helium type) leak detector for leak tests on pressurized vessels or systems. It provides a convenient and economical method of detecting and lo-

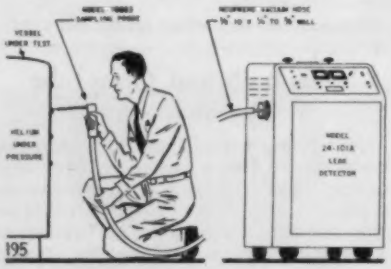


Fig. 1

cating leaks regardless of size, shape or cleanliness of system. In many applications (particularly large-volume systems) this pressure method is even faster and more sensitive than vacuum method. Attainable sensitivity is so

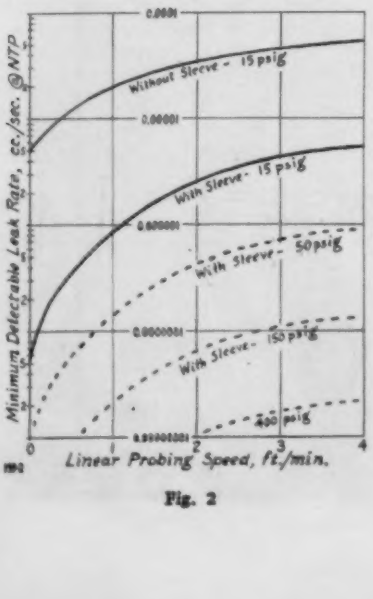


Fig. 2

high that it might be expressed quantitatively as detecting a leak-rate of a cubic inch per century, but maker announcement cautions that sensitivity depends upon: (1) speed at which probe tip is moved over surface, (2) shape of tip and its position with respect to surface, (3) concentration of helium in vessel or system, (4) helium pressure: sensitivity varies approx. as square of abs. pressure. Probe design features adjustable constriction to permit operating leak detector at maximum safe operating pressure; also minimizes "hold-up" so that maximal speeds of response and recovery are attained. Probe is normally installed and used as shown in Fig. 1; performance is summarized in Fig. 2.—*Consolidated Engineering Corp.*, 620 *N. Lake Ave., Pasadena* 4, *Calif.*

Mention No. 615 when filling out card

Hydraulic Scales

New hydraulic scales are of two principal types: (1) Hydraulic force weighing device, Fig. 1, for measuring ten-

Fig. 1

sion or compression loads in such problems as propeller thrust, drawbar pull, jet engine thrust, etc. Three sizes of load cells are available and each can

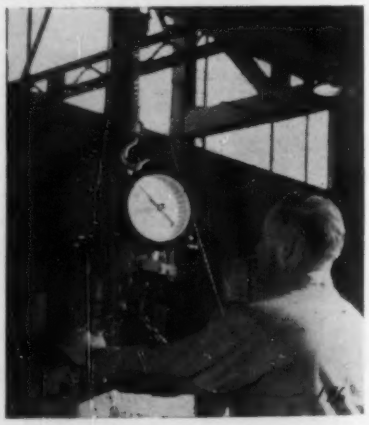


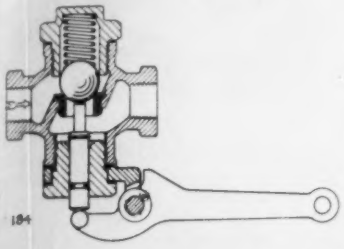
Fig. 2

be employed with a variety of Bourdon gages. (2) Hydraulic crane scales, Fig. 2, designed to weigh loads while suspended from crane. Load capacities range from 0-10,000 lbs. to 0-30,000 lbs. Accuracy of 1 percent of scale reading is claimed.—*A. H. Emery Co.*, 682 *Main St., Stamford, Conn.*

Mention No. 616 when filling out card

Air or Water Operating Valve

New "Type BA-1" self-sealing air or water operating, ball-type valve is fitted with a quick-opening lever which may be adjusted to any horizontal position. Ball valve closes tight with inlet



pressure and will not collect dirt or other foreign matter. Stem is sealed by an O-ring not accessible to tampering or adjustment and eliminates a stuffing-box. It is self-packed by operating pressure when valve is open. Valve is suitable for use up to 200 psi. pressure and temperatures up to 150°F. air and 180°F. water. Valve is constructed with cast semi-steel body, integral rubber seat insert, screwed connections, 0.5 in. size, can be bushed to 0.25 or 0.375 in. —*Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.*

Mention No. 617 when filling out card

Vibration Integrator, Pick-up

New "Type 410-X5" vibration integrator, and new "Type 410-X6" calibrated vibration pick-up, enable con-

venient measurement of vibration displacement, velocity, and acceleration in audio-frequency range. Displacement can be measured from 0.14 microinch to 0.028 in.; velocity from 51.3 microinch per second to 10.3 in. per second; and acceleration from 0.15 in. per second per second to 3900 in. per second per second over a frequency range of 25 to 300 CPS. Response is flat from 60 to 1000 cycles.—*Hermon Hosmer Scott, Inc., 385 Putnam Ave., Cambridge 39, Mass.*

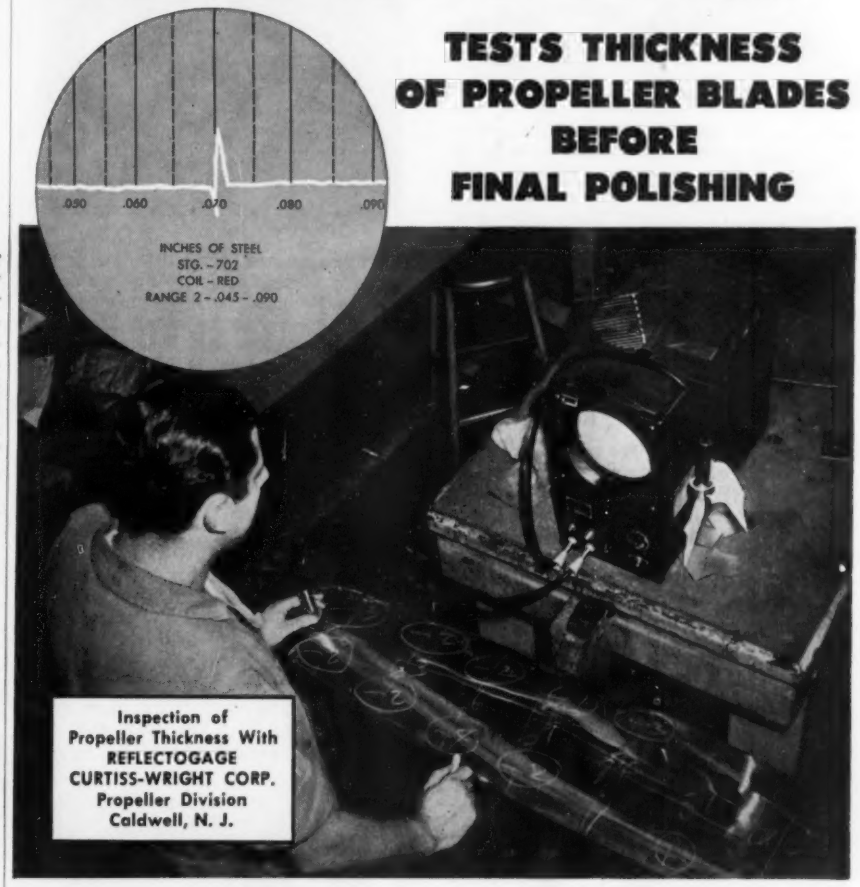
Mention No. 618 when filling out card

Miniature Adjustable-speed Drive

New miniature variable-ratio speed changer weighs less than 6 oz. yet delivers up to 70 oz.-in. torque and 0.025 hp. Applications include recorders, controllers, computers, indicating mechanisms, etc. Ratio of input to output speeds is infinitely adjustable between 1:6 increase and 6:1 decrease. A dial and pointer indicate ratio setting and adjusting knob is equipped with friction drag to prevent ratio wander. Maxi-

SPERRY REFLECTOGAGE

TESTS THICKNESS OF PROPELLER BLADES BEFORE FINAL POLISHING



Inspection of Propeller Thickness With REFLECTOGAGE CURTISS-WRIGHT CORP. Propeller Division Caldwell, N. J.

Leading propeller manufacturers use the Sperry Reflectogage to test the thickness of hollow propeller blades as a guide to final polishing. An inspector checks wall thickness at each blade station. This careful inspection provides a control of wall thickness throughout the blade within established wall thickness limits.

Propeller blades are only one of a large variety of fabricated parts which can be measured by the Sperry Reflectogage. Others include long tubes, formed hollow parts, blades and sheet stock, large tanks and boilers.

Operating on the principle of resonant frequency, the Reflectogage provides an economical means of measuring thickness of parts which formerly were inaccessible for convenient measurement.

In steel, the Reflectogage measures *directly* from .025 to .300 in. thickness, *indirectly* up to 4 in. Other metals and plastics can also be measured. Access from only one side is required. Accuracy is within plus or minus two per cent.

For full information on the Sperry Reflectoscope, write for your free copy of Bulletin 3700-K-6.

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Instantly, accurately locates smaller defects . . . penetrates deeper into metals than any other non-destructive testing device. Saves valuable time lost in machining defective material, minimizes rejects. Read all the facts on the Sperry Reflectoscope in Bulletin 3001-K-6. SP-142

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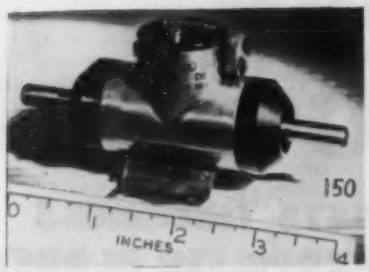


mum output torque is obtainable at zero speed and operating speeds as high as 20,000 rpm. are practical. This variable unit complements maker's fixed-ratio speed changer, so that fixed-ratio gear sections can be supplied integral with variable-ratio unit to obtain any nominal output speed range.—*Metron Instrument Co.*, 432 *Lincoln St., Denver 9, Colo.*

Mention No. 619 when filling out card

6-ft. Folding Rule

New enameled 6 ft. zig-zag folding rule made of a special hardened and tempered alloy steel, can be bent and twisted yet will always spring back to its normal shape. Weighs less than aver-

age wood rule. White enamel finish is baked at over 500 deg., much higher than on other types of folding rules. Rule will not bend or break. Does not have to be closed each time it is used to prevent breakage.—*Durall Tool Corp.*, 117 *Woodworth Ave., Yonkers, N. Y.*

Mention No. 620 when filling out card

Slow-speed Stroboscope

New 'Type 1532-A Strobolume" is a high-intensity short-flash stroboscope designed primarily for stroboscopic observations on machinery operating at relatively low speeds, such as textile looms, printing presses and fuel injection systems. With "Strobolume," even a single, isolated flash produces a definite stationary image of moving object, so that stroboscopic method of analysis can be extended to cover low-speed mechanisms satisfactorily. "Strobolume" is designed to be flashed from an external contactor, and hence is particularly useful where motion to be examined is related to angular position of a shaft, on one end of which a contactor

is held or clamped. A push-button is provided for tripping single flashes manually. "Strobolume" will operate continuously at speeds up to about 45 flashes per minute.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*

Mention No. 621 when filling out card

A-c. Clamp Volt-ammeter

New "Model 633 Type VA-1" a-c. clamp ammeter and voltmeter, with five current ranges up to 1,000 amps., and three voltage ranges up to 700 volts is designed to measure without interrupting electrical service. Current measurements are made simply by placing heavily-insulated trigger-operated clamping jaw around conductor. Jaws will accomodate conductors, bare or insulated, up to 2 in. in diameter. Voltage measurements are made by con-

necting a set of clip-on voltage leads (six-foot leads are supplied) to line, and to screw-type terminals recessed in side of instrument. Current and voltage measurements can be made almost simultaneously by rotating thumb-selector switch to either ampere or volt position. A pointer stop shows motor-starting currents. To prevent shorts when measuring current on bare conductors, jaws are insulated with tough rubber sleeves. Jaws can be operated by one hand when making current measurements. Instrument has a rated accuracy within three per cent of full scale range (this applies to each of eight ranges) when used on frequencies between 50 and 70 cycles.—*Weston Electrical Instrument Corp.*, 617 *Frelinghuysen Ave., Newark* 5, *N. J.*

Mention No. 622 when filling out card

Metal Desiccator

New "No. 5510" desiccator is fast-cooling, constructed of aluminum instead of glass and has a high heat capacity because bottom and wall sections average about 0.5 inch in thickness. Desiccant is silica gel stored in 500-mesh wire-cloth-bottomed pan clipped inside cover—*Harry W. Dietert Co.*, 9330 *Roselawn Ave., Detroit* 4, *Mich.*

Mention No. 623 when filling out card

Surveying Altimeter

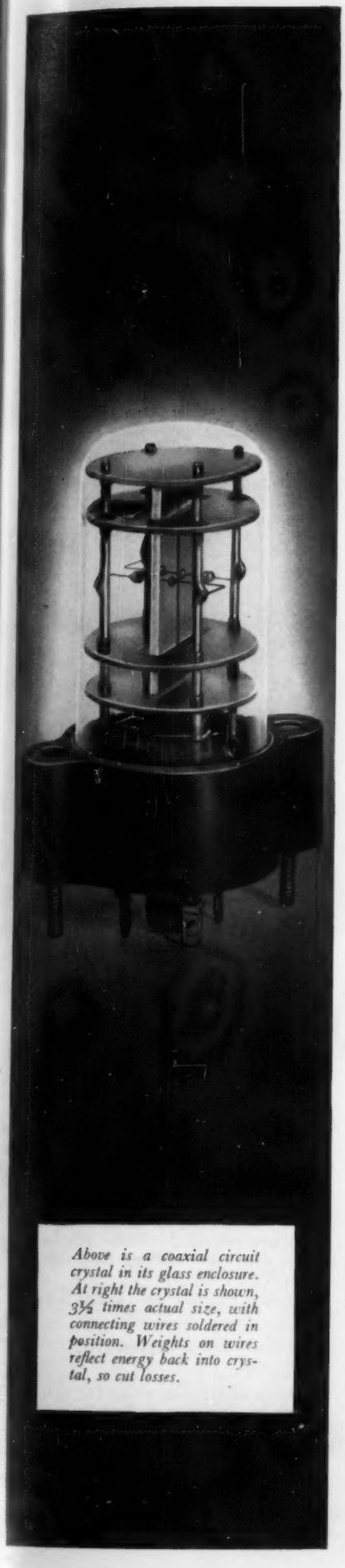
New "Type FA-185 Sensitive Altimeter" is a durable surveying instrument, shock-proofed in a metal case. A leather

carrying case with shoulder strap gives adequate protection against rough handling in field. There is a means of sealing instrument to protect it during storage or in transit. A self-contained armored thermometer is supplied. Standard ranges are 6,000 and 15,000 feet and special ranges are available to order.—*Wallace & Tiernan Products, Inc., Belleville* 9, *N. J.*

Mention No. 624 when filling out card

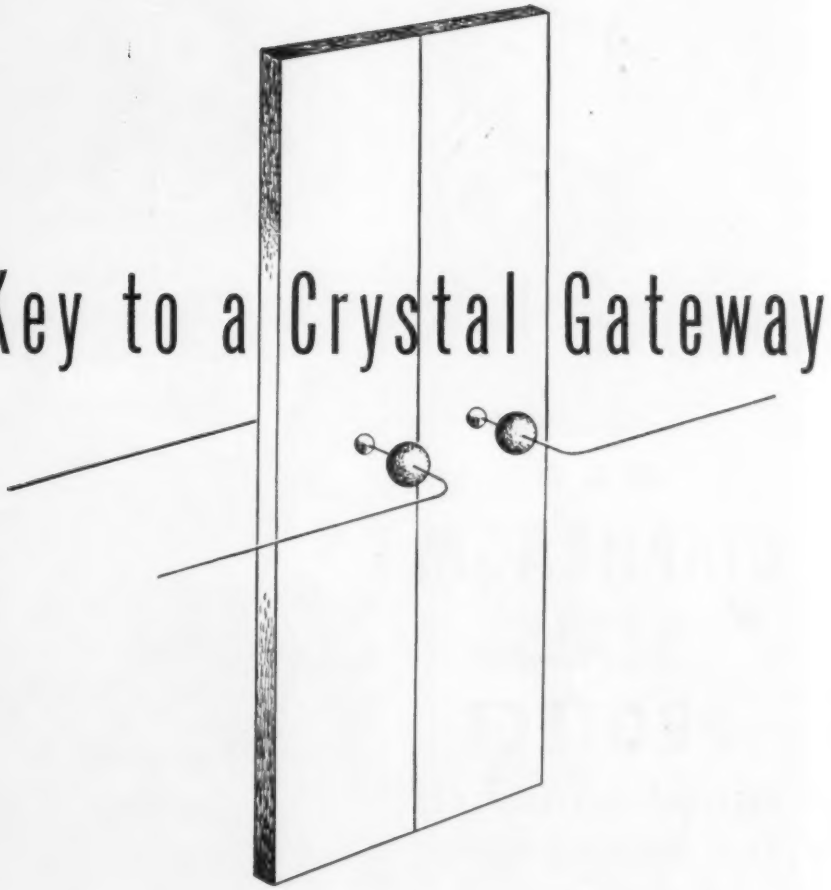
Multi-purpose Magnet

New magnetic probe, said to be "made of super-magnetic alloy," is no larger than a fountain pen. Point of magnet is extended or retracted from streamlined polished Bakelite case by turning end-knob. Strength of magnet can be controlled by amount of extension. Pocket clip is provided. Probe is useful for removing steel or iron particles from areas where such foreign matter is harmful, such as operating area of electrical instruments. Plant first aid stations can use probe to remove steel splinters from eyes or skin of employees. Nurse or doctor can adjust



Above is a coaxial circuit crystal in its glass enclosure. At right the crystal is shown, 3½ times actual size, with connecting wires soldered in position. Weights on wires reflect energy back into crystal, so cut losses.

Key to a Crystal Gateway



How would you solder a wire to a crystal? This must be done for most of those wafer-thin plates of quartz used in electrical circuits. They play a big part in the myriad-channel telephone system that utilizes coaxial cables.

This is how Bell Laboratories scientists solved the problem: A spot of paste containing silver is deposited on the crystal and bonded to it by oven heat. The crystal is then vapor-plated with a thin layer of silver. Then a fine wire is soldered to the spot by a concentrated blast of hot air. The result is a rugged electrical connection to the surface of the crystal which does not interfere with its vibrations.

Sealed in glass tubes, the crystals are precise and reliable performers in the telephone system. Each is a crystal gate to a voiceway, separating *your* conversation from the hundreds of others which may be using a pair of coaxial conductors, at the same time.

This spot of paste, this tiny wire, this puff of air are among the tremendous trifles which concern Bell Telephone Laboratories in finding new ways to improve your telephone service.

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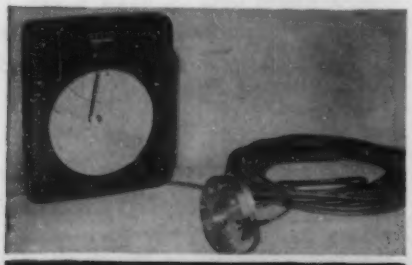

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strength of magnet for proper extraction to reduce pain or rupture of tissues. Probe can be sterilized without harming magnet.—*General Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa.*

Mention No. 625 when filling out card

Impedance Bridge

New "Type 916-AL" impedance bridge has nominal range of 50 kc. to 5 Mc. and may be used down to 15 kc.

in testing resistors, capacitors, antennas, etc. Instrument reads directly in resistance units and in reactance directly at 100 kc. Of particular usefulness in supersonics and low r-f. work, bridge has resistance range of 0 to 1,000 ohms; reactance range at 100 kc. is 11,000 ohms.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Mention No. 626 when filling out card

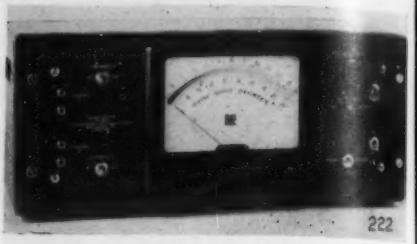
Microwave Meter

New "Microwave Mega-Match" extends "Mega-Match" method of displaying reflection coefficients over a broad band to X-band. Range is 8500 to 9700 Mc. per sec. Instrument includes delay wave guide approximately 75 ft. long formed into shape 8 x 1 ft., calibrated X-band wave meter, power supply and controls. Frequency sweep up to 10 Mc. is available and changes down to 0.02 are indicated.—*Kay Electric Co., Pine Brook, N. J.*

Mention No. 627 when filling out card

Phase Meter

New "Type 320-A" phase meter is said to be first instrument available for measuring phase differences between

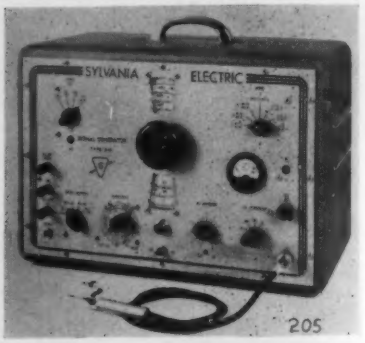


two voltages at audio and supersonic frequencies, essentially independent of voltage amplitude, frequency and wave shape; has four full-scale ranges of 360, 180, 90 and 36 deg. with 180-deg. phase-reversing switches provided. Operation is based on pulse method and range is 20 cycles to 100 kc. Accuracy is within 2 percent of full scale.—*Technology Instrument Corp., Waltham, Mass.*

Mention No. 628 when filling out card

FM-AM Signal Generator

New FM-AM signal generator providing a high-level r-f. signal source ranging from 80 Kc. to 120 Mc. for



alignment of FM and AM radio receivers, may be used by either standard AM alignment method or more highly efficient FM method utilizing an oscilloscope. An r-f. output meter plus step-by-step and smooth attenuator controls are provided—*Radio Div. of Sylvania Electric Products Inc., 500 Fifth Ave., New York, N. Y.*

Mention No. 629 when filling out card

Noise Generator

New "Type 810-A" noise generator is a source of random noise for use in research engineering and production testing. It provides a random noise with equal power in equal bands throughout audio-frequency spectrum and a substantial radio-frequency output if desired. A switch enables a noise output conforming to "Noise of a General Character" as specified by ASA. This

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These examples serve to emphasize the scores of different ways DPI high vacuum equipment is enabling new products and better products to be made at lower costs.

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range is particularly useful for calibrating sound level meters. Conveniently operated with maker's "Type 20-A" power supply, "Type 810-A" has an audio-frequency output voltage from 0 to 0.2 volts. Frequency range is 30 to 500,000 cps. in r-f. range and 30 to 20,000 cps. in a-f. range.—*Hermon Hosmer Scott, Inc.*, 385 *Putnam Ave., Cambridge* 39, *Mass.*

Mention No. 630 when filling out card

Dual-voltage Insulation Tester

New "Model 101 Megotron" is a rectifier-type dual-voltage three-range instrument for use in measuring insula-

tion resistance of power plant, substation and underground equipment. Instrument operates from 110-130-volt 50-60 cycle a.c. and supplies either 500 or 1000 volts d-c. test voltage. Megohm ranges at 500 volts are 0.1-5; 3-200 and 15-2000 megohms. At 1000 volts, ranges are 0.1-5; 3-200 and 30-2000 megohms. —*J. W. Dice & Co., Grand View-on-Hudson, N. Y.*

Mention No. 631 when filling out card

Vacuum Tube Voltmeter

New "Type 221" vacuum tube voltmeter, with range and accuracy particularly appropriate for servicing television and high-fidelity audio circuits as well as measurement of a wide range of voltage, current and resistance

values in standard broadcast receivers, provides an essentially flat response in voltage measurements at frequencies ranging from 20 cycles to 300 Mc. Six scales provide convenient ranges for a-c. measurements from 0-3 to 0-1000 volts and these ranges may be multiplied by a factor of 10 by means of a 30-kv. accessory probe. A-c. voltage measurement of 0-3 to 0-1000 volts is also accomplished through the use of six scales. Five rf. ranges permit measurements of 0-3 to 0-300 volts.—*Radio Div., Sylvania Electric Products Inc., 500 Fifth Ave., New York 18, N. Y.*

Mention No. 632 when filling out card

Portable A-c. Bridge

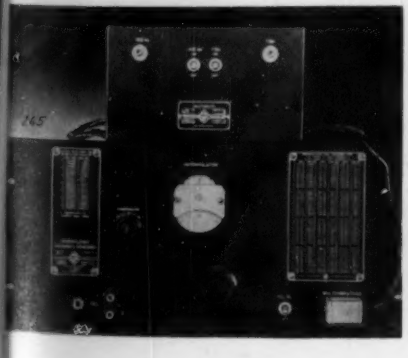
New "Type RB Solu-Bridge" is light weight, entirely self-contained, dry cell operated, and is available in some 80 different ranges and calibrations. Instrument is an a-c. wheatstone bridge provided with a manual temperature compensator and a main scale cali-

brated either in conductance units or in terms of concentration of some single electrolyte. An electron ray "eye" tube is utilized as null indicator.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Mention No. 633 when filling out card

UHF Interpolator

New "Type 1110-A" interpolating frequency standard, for use with heterodyne frequency meters in making accurate frequency measurements at ultra-high frequencies up to about 3,000 Mc., provides over-all accuracy of about 0.001 percent. Instrument provides a series of harmonics of a nominal 1-Mc. signal, whose fundamental is adjustable over a range of 1 percent. Complete coverage from one harmonic to next is obtained. Consequently, when a fre-



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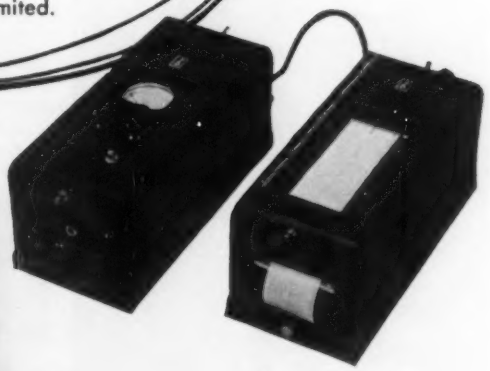

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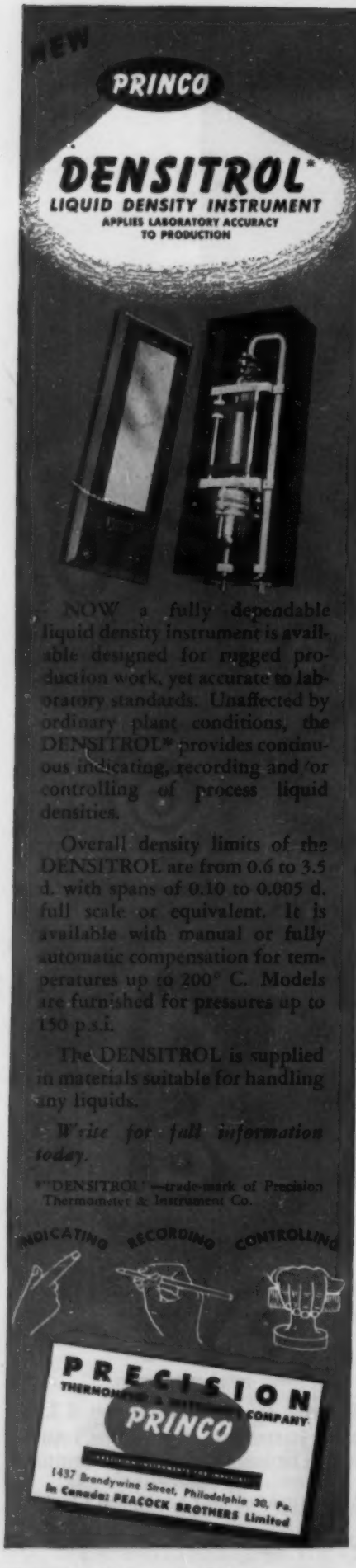
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quency lying between 100 and 200 Mc. is measured approximately on a frequency meter, it can be matched and determined accurately with new interpolating frequency standard. — *General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Mention No. 634 when filling out card

Geiger-Muller Scaler

New "Model 1000-B" Geiger-Muller scaler weighs 14 lbs. and is smaller than a portable typewriter. Stability in counting circuits has been provided by employing throughout parallel filament and heater circuits and also by newly designed bias arrangements. R-f. high-voltage power supply is regulated to 0.1 percent. Plug-in construction with miniature tubes has made scaler extremely portable. It incorporates outlet plugs for accessories such as automatic scaling unit, electric time clocks, loudspeaker, automatic timers and other units. Scaler also provides ease of operation through direct-reading decimal scale of 1,000 and 100 and a zero reset mechanical register.—*Berkeley Scientific Co., Sixth St. and Nevin Ave., Richmond, Calif.*

Mention No. 635 when filling out card

Automatic Scaler

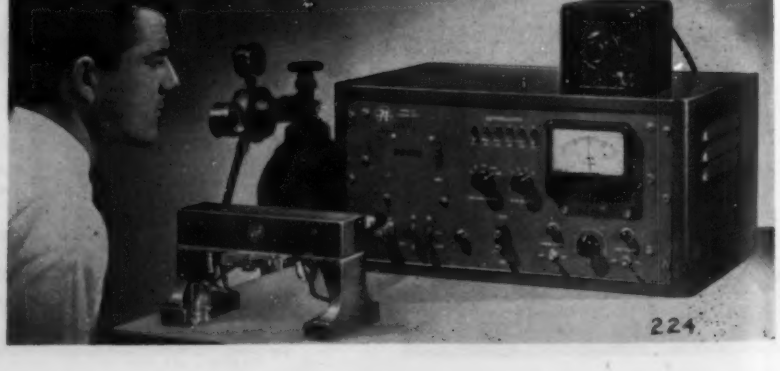
New "Model 2000" automatic Geiger-Muller scaler represents a departure from laboratory instruments available at present. Number of counts is read directly on front panel, eliminating need for interpolation. A decimal scale of 1,000 is used in combination with a new direct-reading mechanical register with zero reset. High-voltage power supply is said to be regulated to 0.005 percent and is of new "RF type." A direct-reading electric time clock is built-in. Automatic operation for predetermined number of counts (up to 20,000) may be reset by selector knob on front panel. An accessory timer is available for automatic operation for predetermined time intervals. Entire circuit is divided in 7 removable plug-in units which afford complete accessibility and permit rapid exchange, testing and servicing. Three decimal counting units are used to form scale-of-1,000. Other plug-in units contain high-voltage power supply, voltage regulator circuits, input amplifier and output amplifiers. Forced-air cooling is provided by a quiet built-in fan.—*Berkeley Scientific Co., Sixth St., and Nevin Ave. Richmond, Calif.*

Mention No. 636 when filling out card

Radioactivity Instrumentation Assemblies

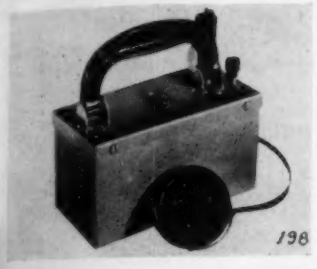
New laboratory set-ups provide complete facilities for routine radioactivity counting or research work. "Model L-165" is a basic group which includes a complete scaling unit, a thin-mica end-window Geiger tube, a convenient tube mount, and necessary connecting cables and sample dishes to permit radio-tracer research: all essential equipment for demonstration as well as for laboratory work. A "Model SM60" timer is also suggested. "Model L-163," known as "Radioisotope Analyst" group, especially designed for analysis of radioactivity, includes a complete automatic scaler, plus a Q-gas counter. With it, precise work can be done with low-activity low-energy samples, and group is therefore suited for medical, chemical, and physical research work. When used with timer, operation is completely automatic. Either predetermined time or predetermined count operation can be accomplished without attention from technician.—*Nuclear Instrument and Chemical Corp., 223 West Erie St., Chicago 10, Ill.*

Mention No. 637 when filling out card



Geiger-Muller Counter

New Geiger counter, sensitive to both ta and gamma rays, employs a 900- lt plug-in type Geiger tube with a mg. per sq. cm. thin window section ich makes possible detection of beta rticles as low as 160 kev., as well as



mma rays. Instrument is equal in nsitivity to laboratory equipment. It designed primarily for field use in ating radioactive ores. Life of bat- y is one year and life of Geiger e is more than one hundred million nts. Crystal earphone and battery included.—*Precision Radiation In- uments, Inc.*, 1101 *North Paulina St., icago 22, Ill.*

Mention No. 638 when filling out card

Radioactivity Meter

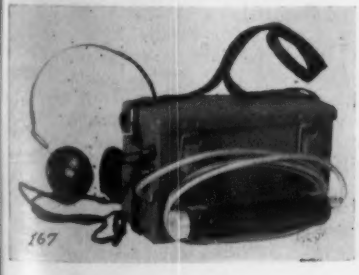
New "Model K-320 Alpha-Beta- mma Portable Survey Meter" has artz-fiber electrometer said to be ex-

ptionally accurate for gamma meas- ements. A plastic window with uivalent thickness of 25 mg. per sq. n. is employed for beta measurements d a nylon window of 2 mg. per sq. cm. uivalent thickness for alpha measure- ents.—*Kelley-Koett Mfg. Co.*, 212 *W. ourth St., Covington, Ky.*

Mention No. 639 when filling out card

Portable Radioactivity Detector

New "Type PRD1 Radioactivity De- ctor" is a low-cost portable instrument id to be first available with accuracy



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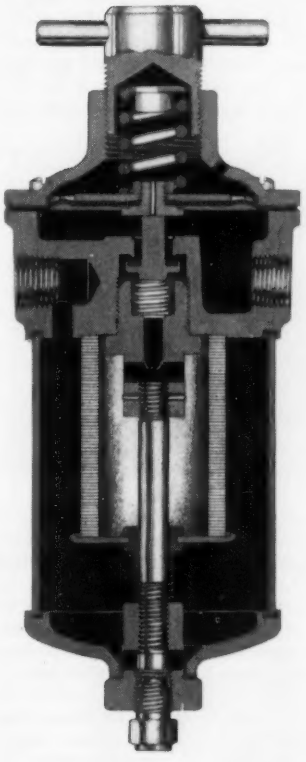

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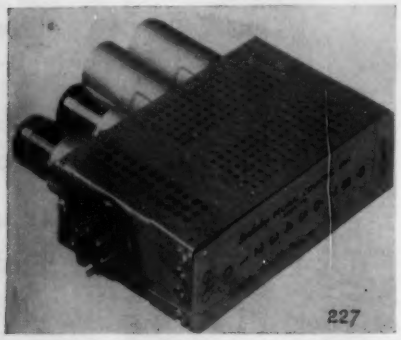
Mention No. 640 when filling out card

High-speed Counter

New "Model 700" high-speed electric counting unit is a compact four-tube plug-in unit which contains a scale-of-ten counting circuit capable of operating at counting rates in excess of 40,000 pulses per second and of resolving

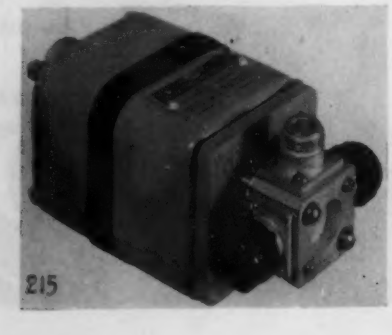


pulse pairs spaced less than 5 microseconds apart. Number of counts is read from 10 neon indicator lamps mounted behind a Lucite front panel which is numbered from 0 to 9. Each count is indicated directly by illuminating neon lamp corresponding to number of pulses received. Any number of decimal counting units may be cascaded to count to any desired number. Thus by mounting several units next to each other, number of counts may be read directly. If, for example, four units are used, a total of 7,059 counts fed into first unit will cause numerals 7, 0, 5 and 9 to light up in first, second, third and fourth units, respectively. All units may be reset to zero by opening a momentary contact switch connected to bias supply. —*Berkeley Scientific Co., Sixth St. and Nevin Ave., Richmond, Calif.*

Mention No. 641 when filling out card

Coaxial Switches

New line of coaxial switches with solenoid drive for remote control or with manual control for panel mounting are compact and light in weight. For use in aircraft, radar and tele-



vision applications. S-p. switches are available in 2-way to 6-way for use with various cables. All models accept type "N" connectors. Standing wave ratio is less than 1.25 to 1 to 3,000 Mc with peaks of not more than 2.0 to 1 to 10,000 Mc. Crosstalk attenuation is not less than 60 db. to 3,000 Mc., and not less than 40 db. to 10,000 Mc.—*Designers for Industry, Inc.*, 2915 *Detroit Ave., Cleveland* 13, *Ohio.*

Mention No. 642 when filling out card

Regulated D-c. Power Supply

New "B-Nobatron" voltage regulator is a highly-stabilized source of high-voltage low-amperage d.c. Instrument

may be housed in a metal cabinet or mounted on a standard relay rack. It gives regulation accuracy to within 1 percent; is equipped with convenient controls and is amply protected against overload conditions. —*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

Mention No. 643 when filling out card

Twin Power Supply

New "Model 610-F" twin power supply provides d-c. output of 0 to 32[illegible] volts from 115 volt a-c. input, either as a single source variable from 0 to 120 milliamps., or as two sources adjustable from 0 to 60 milliamps. Output is said

to vary less than 1 percent under line fluctuations from 105 to 125 volts, and internal impedance is no more than 20 ohms shunted by a capacitance of at least 4 mfd. for dual-range operation or 8 mfd. for single-range operation. Ripple is less than 10 millivolts. Instrument also provides a-c. output either of 6.3 volts at 6 amps. or 12.6 volts at 3 amps. Controls include two knobs for regulating voltage. Instrument draws 200 watts current and has two 3-in. meters.—*Furst Electronics*, 12 *S. Jefferson St., Chicago* 6, *Ill.*

Mention No. 644 when filling out card

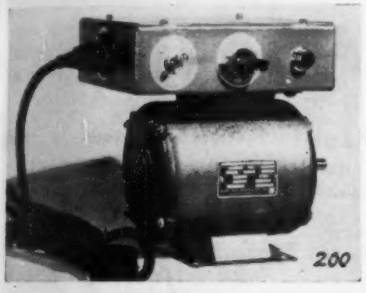
Combination Watthour and Thermal Kva Demand Meter

New "Type IHE-1A" combination watthour and thermal kva. demand meter for use by electric utilities having rate structures requiring the measurement of kva demand is essentially same size as a conventional watthour meter; hence it can be installed without increasing the size of the original installation. It is available in the 50-amp. 240-volt 3-wire single-phase rating. Watthour meter is essentially the "I-50" (see May 1948 issue, page 416) except that rotating element is of the conventional ball-bearing type. Thermal demand meter unit consists of thermal unit, current transformer, resistance valve, potential transformer for exciting heater of resistance valve, and driving mechanism, pointers, and scale.—*Meter and Instrument Divisions, General Electric Co., West Lynn 3, Mass.*

Mention No. 645 when filling out card

Three-speed Synchronous Motor

New "Model GH-371," reported to be first practical three-speed hysteresis-type synchronous motor, provides three

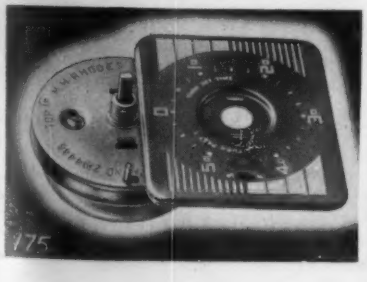


synchronous speeds in one unit, saving in equipment cost and space, and facilitating testing and experimentation. Operation is switch-controlled (or can be relay-controlled) providing for clockwise or counter-clockwise rotation. It is not only reversible while running, but can also change from one speed forward to a different speed reverse. Rated at 0.01, 0.0166, and 0.025 h.p., respectively, at 900, 1800, and 3600 rpm. Operates from 115-volt, 60-cycle, single-phase a.c. —*Electric Indicator Co., Stamford, Conn.*

Mention No. 646 when filling out card

Mechanical Timer

New "Mark-Time" two-speed mechanical timing device may be used for either a 60-minute or 6-minute period, as compared to previous timers which could be used for one timing cycle only. Device can be incorporated in kitchen ranges, electrical appliances,



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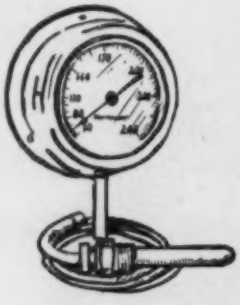

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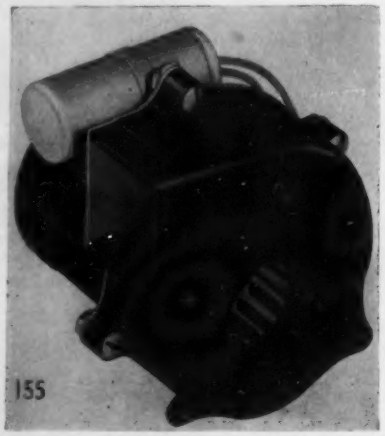
and other household and industrial equipment. Shifting from one timing cycle to another is accomplished merely by flicking a small lever. For both 6-minute and 60-minute timing, full 360° sweep of dial is employed. Each dial is divided into 6 major divisions. Numerals feature a large first digit and a small zero. Thus, first division indicates 1 minute on 6-minute operation and 10 minutes when on the 60-minute cycle. A bell tone signal marks end of a time period. Other special timings can be supplied in the 10-to-1 ratio.—*M. H. Rhodes, Inc., Hartford, Conn.*

Mention No. 647 when filling out card

Instrument-cabinet Blower

New "Model 805J" small centrifugal blower is extremely smooth and quiet in operation due to its synchronous hysteresis motor, accurately balanced fan and special anti-vibration mounting. It is designed for vacuum tube cooling and



for ventilating small enclosed areas. Over-all dimensions, 4.375 in. x 3.9375 in. x 3.84375 in.; weight, 24 oz.; air delivery, 20 cfm; voltage, 115, 60-cycle a.c.; current, 0.150 amps.; speed, 3,599 rpm.; input, 15 watts.—*Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.*

Mention No. 648 when filling out card

Variable-speed Motor-control System

New system for stepless speed control of fractional-horsepower motors employs a simplified circuit said to make

possible "for the first time" electronic control without sacrificing desirable operating features. Power unit operates from 110- or 220-volt 50-60-cps. source, utilizes full-wave gaseous rectification to supply both armature and field of a specially-designed ball-bearing d-c. mo-

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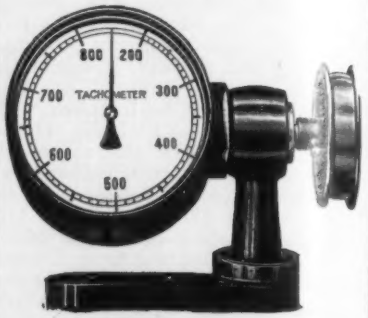

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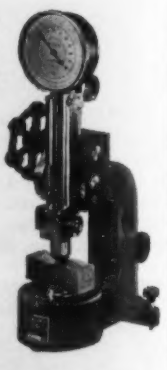

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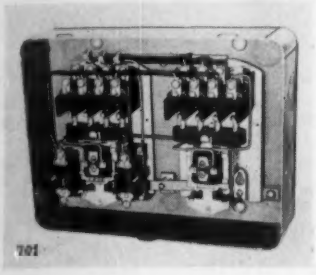
tor. Control unit is cigarette-pack-size, may be located remotely from power unit and from motor, permits selecting any speed over a range greater than 20-to-1. (80-1800-rpm. standard, others available). Also included on control unit is an "idle" switch to start or stop motor without changing speed setting. Reversing control units are available. Specially-designed motor in connection with dynamic braking makes possible full speed reversals within one second in some applications. Two available models include various motors up to 0.5 hp. Most types are available for immediate delivery from stock.—*Servo-Tek Products Co., 4 Godwin Ave., Paterson 1, N. J.*

Mention No. 649 when filling out card

Reversing Starters

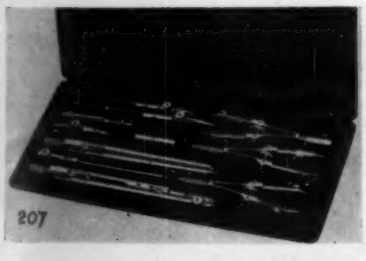
New line of a-c. magnetic reversing starters (across-the-line type) is designed for control applications such as machine tools, woodworking machines, etc. Starters with three poles are available for across-the-line starting and reversing of polyphase motors to 200 h.p., 550 volts, 60 cycles inclusive. Four-pole starters with ratings of 7.5 hp., 550 volts, 60 cycles maximum are suitable for use with externally reversible single-phase motors of four-wire split phase, capacitor or repulsion induction types. Starters consist essentially of two magnetic contactors interwired for reversing operation, mechanically interlocked, with or without thermal overload protection.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*



Mention No. 650 when filling out card

Drafting Instruments

New drafting instruments of Swiss manufacture, are available in different combinations and various grades for use by architects, draftsmen, engineers. Typical set illustrated includes two ruling pens, screwdriver, leadholder, compass pen, divider, extension bar for compass, compass, bow divider, bow pen and bow pencil. Instruments are made of triple-plated chrome over hard nickel silver and are also available in solid nickel silver and brass nickel-plate. Features include an adjustable lead



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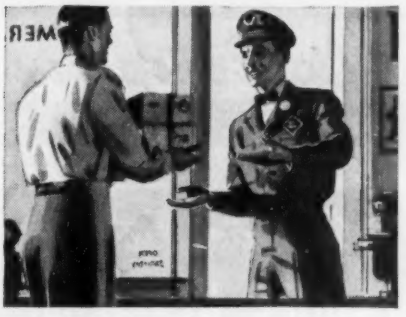

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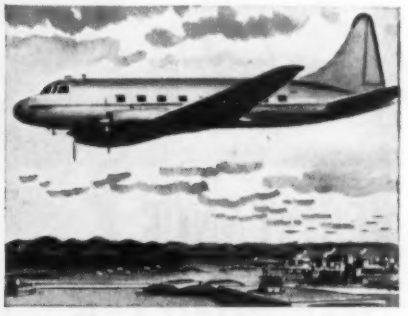

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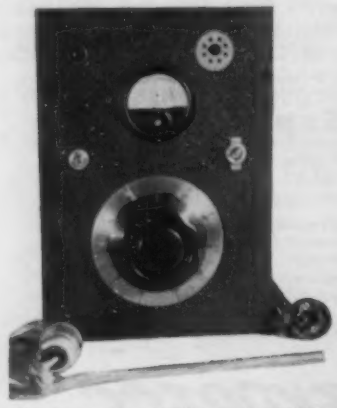

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chuck in compass, permitting use of all types of lead, precision center control wheels for hairline adjustments of instruments; dividers with either standard or hair springs.—*Borden and Riley Paper Co., Inc., 60 East 11th St., New York 3, N. Y.*

Mention No. 651 when filling out card

Hardness Test Blocks

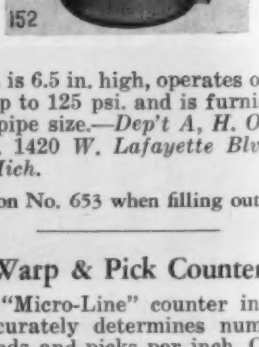
New series of precision test blocks, while specifically manufactured for use with maker's "Rockwell" hardness test-

ing machines, give accurate results on any Rockwell type hardness tester. Blocks are available in hardness grades for all Rockwell scales and limits covered by each block are clearly stamped on edge. A deluxe master diamond checking set also available includes a gold plated diamond penetrator and two test blocks.—*Clark Instrument, Inc., 10200 Ford Road, Dearborn, Mich.*

Mention No. 652 when filling out card

Automatic Steam Trap

New "No. OX" small steam trap, for applications where minimum size and large capacity are desired, weighs six

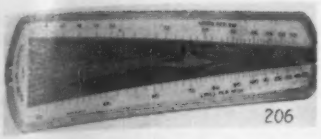


pounds, is 6.5 in. high, operates on pressures up to 125 psi. and is furnished in 0.5 in. pipe size.—*Dep't A, H. O. Trerice Co., 1420 W. Lafayette Blvd., Detroit, Mich.*

Mention No. 653 when filling out card

Warp & Pick Counter

New "Micro-Line" counter instantly and accurately determines number of warp ends and picks per inch. Counter consists of multiple layers of transparent plastic, surrounded by a satin-finished brass or gold-plated metal frame. On field is engraved a series of precise converging lines; along sides

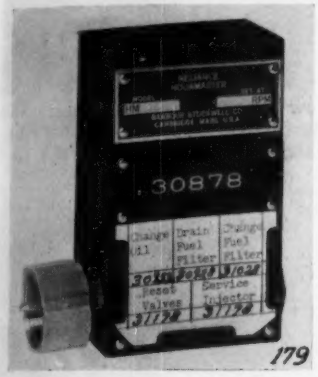


e calibrations showing number of es per inch and lines per centimeter. odifications of this instrument are vailable as mesh counters, halftone reen counters, etc. — *Micro-Lite Co.*, c., 44 *West 18th St., New York* 11, Y.

Mention No. 654 when filling out card

Time Recorder

New "Hourmaster" records time of eration of machinery by converting m. into hours which are indicated on

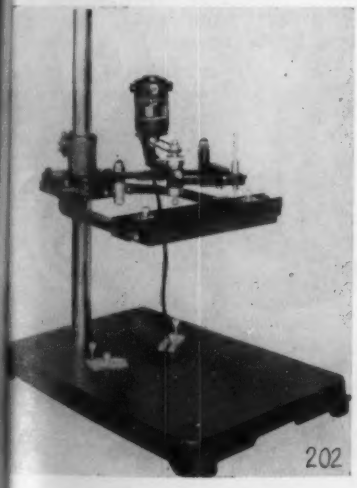


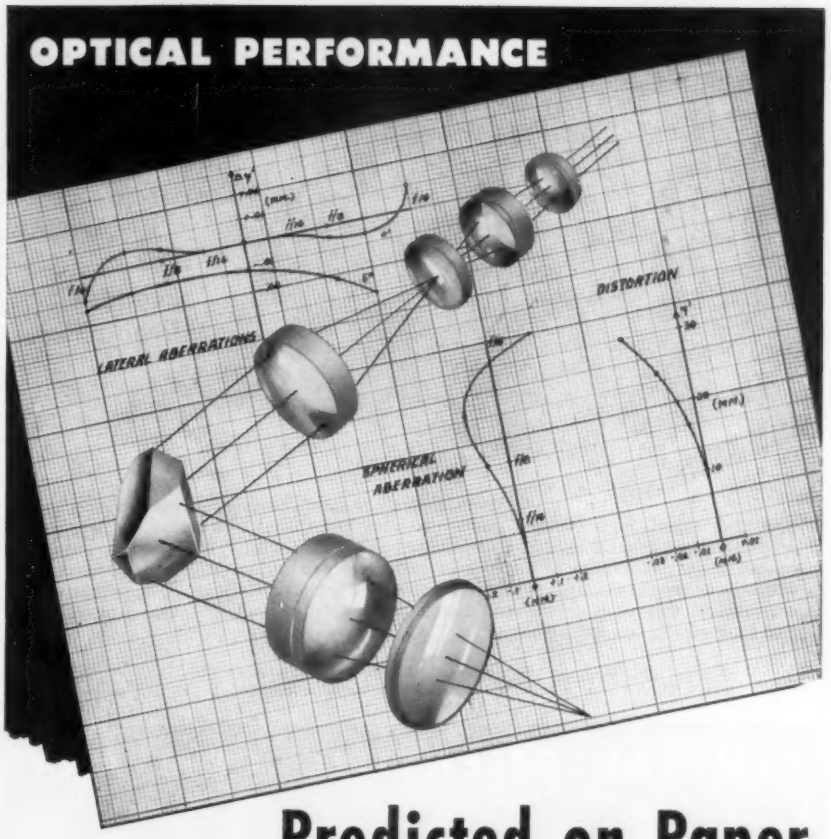
it dial as illustrated. Instrument ds to 100,000 hours and operates in nge of 1 to 4,000 rpm. Said to be use- l in checking operating time against own" time, intervals between re- acement of parts, etc. Cards and lder are provided for recording data front of case.—*Barbour-Stockwell o., Cambridge* 39, *Mass.*

Mention No. 655 when filling out card

Small Engraver

New "Model 253" engraver is an im- ovement of maker's "Model 252." It creases scope of small engraver so at it now can be used on work up to in. high. A "V" groove slot incor- rated in support post enables ma- ine to be swung away from work d reset in exact location as before. ntograph unit is same as that of





Predicted on Paper

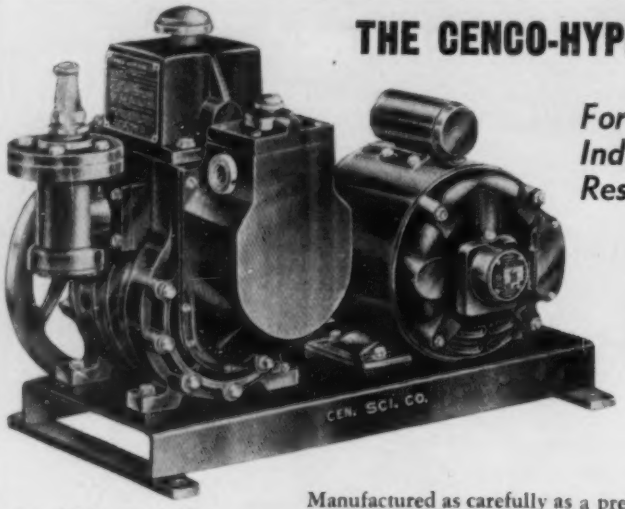
SHOWN above on a background of the aberration curves with which American Optical Company scientists predict lens performance, is a special optical system designed for use with an elaborate machine tool.

Many such systems can be economically produced using stock optics from Spencer Scientific Instruments. Others must be specially designed. In either case, our long experience, large staff of optical specialists, and extensive manufacturing facilities are the best assurance of satisfaction for the manufacturer who has problems of an optical nature.

Write Dept. T32 for details.

American Optical
COMPANY
Scientific Instrument Division
Buffalo 15, New York

Manufacturers of the **SPENCER** *Scientific Instruments*



THE CENCO-HYPERVAC 25

For Industrial Research

For Economic Production

Manufactured as carefully as a precision watch, this new high speed, high vacuum pump provides fast initial evacuation for research or production. It combines in a single mechanical unit, ability to pump at a speed of 264 liters per minute of free air or 120 liters per minute at 1 micron pressure and attains an ultimate pressure well below 0.1 micron. Here is a pump that will perform reliably with or without a second stage diffusion pump. Quiet operation and long service are assured.

Write Dept. B.U. for Engineering Bulletin 10A describing Cenco High Vacuum Pumps, Gages and accessory equipment.

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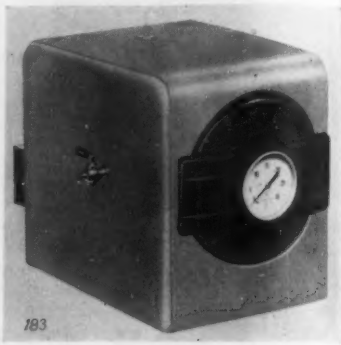
"Model 252." Another advantage that spindle is close to work, thus reducing any possibility of vibration to whip of cutting tool or tool holder. Micrometer spindle is also furnished as standard equipment. Sub-base, with pantograph, can be removed from support post and used as a portable engraver. Both base and sub-base are cast iron with accurately ground surface. Base is drilled and tapped to facilitate set-up of mounts or special fixtures; sub-base has machined "V" ways for holding copy carriage. Copy carriage fits "V" grooves on sides of pantograph and base assembly, is quickly adjusted and is always maintained parallel by simply tightening one screw. Two sizes of master copy blanks, 0.75 and 1.5 in., can be held by carrier. Type stop clamp the master type in place by turning of a knurled thumbscrew.—*Micro Instrument Co., Cambridge* 38, *Mass.*

Mention No. 656 when filling out card.

Laboratory Oven

New vacuum oven designed especially for use in small laboratories provides shelf space 4 in. wide x 7 in. long

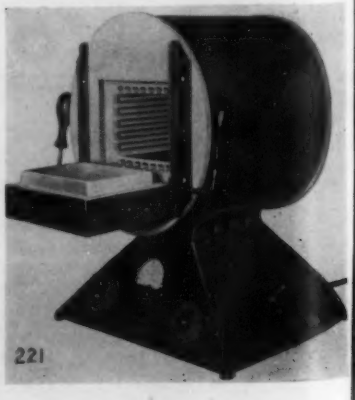


x 5 in. high. Oven features "black-heat" heating elements with a "life-time guarantee." Uniform temperature is assured by a new design in placing an air cock on each side which provides a cross flow of dried air, thereby removing moisture rapidly and completely.—*National Appliance Co., Swan Island, Portland* 18, *Ore.*

Mention No. 657 when filling out card.

Muffle Furnaces

New furnaces designed primarily for drying precipitates, ash determinations, fusions, ignitions, experimental work, etc., depart from usual rectangular shape, being housed in a cylindrical

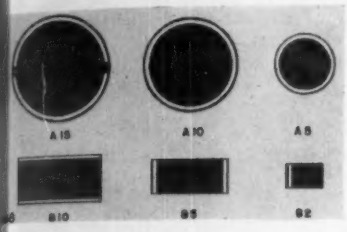


ll mounted on a pyramidal type e. Among improvements are: (1) truments and controls at approxiely room temperature; (2) Improvinsulation design cuts radiation loss; 36-step control; (4) Instruments ly accessible through removable els.—*Hevi Duty Electric Co., Milkee 1, Wis.*

Mention No. 658 when filling out card

Selenium Photocells

New photoelectric cells embody metal nks coated with layers of selenium platinum for detection of light and

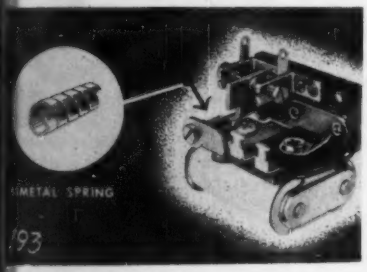


ration of signaling devices through ys. Cells are for incorporation in osure meters, street-lighting sys-s, smoke detectors, etc. They have a itivity of 600 microamps. per lumen are available in rectangular sizes m about 0.5 by 0.75 in. and in round s of 1.75 in. diameter and larger. s are said to show no indication of igue after continuous exposure to t in order of 200 foot-candles.—*International Rectifier Corp., 6809 South toria Ave., Los Angeles 43, Calif.*

Mention No. 659 when filling out card

Temperature Compensated Relay

New relay developed for battery rge control where operating voltage st decrease with rising temperature,



ntains voltage settings plus or minus ercent with 25 milliwatts operating er. Windings are available for all mon charging voltages. Same conuction also makes available a new retype giving operation at essentially stant voltage from minus 50 to plus C., useful in a variety of control cirs. Adjustments are offered for voltfrom 0.01 volt up, at sensitivities of 25 mw.—*Sigma Instruments, Inc., Ceylon St., Boston, Mass.*

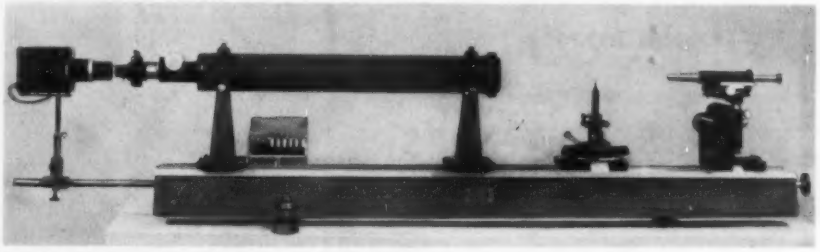
Mention No. 660 when filling out card

Midget Relay

New "Type 637-57A" hermetically ed relay is provided with a standard al plug having a metal locating pin glass-to-metal seal on plug pins. y combines light weight and midsize with complete protection from

Gaertner

OPTICAL BENCHES



L360N PRECISION OPTICAL BENCH ASSEMBLY

For accurate measurement of

Focal length	Astigmatism	Spherical aberration
Resolving Power	Curvature of field	Chromatic aberration
Distortion	Coma	(Lateral and axial)

STANDARD EQUIPMENT INCLUDES:

HEAVY LATHE BED TYPE BENCH made of normalized meehanite, sufficiently cross ribbed to provide ample rigidity. Ways are ground and scraped for straightness and close fit of carriages. A millimeter scale 160 cm long is mounted on the side. The bench is 167 cm long, 11 cm wide, 15 cm high.

COLLIMATOR incorporating a highly corrected achromatic objective of 80 mm aperture and about 915 mm focal length, targets, monochromatic filters and a light source.

NODAL SLIDE CARRIAGE providing a linear motion through 30 mm, a vernier and scale reading to 0.05 mm, and angular motion through 360°, readable to 1°. A variable length remote control rod permits rotation of slide from observer position at the microscope.

MICROSCOPE capable of motion vertically, horizontally, and along its axis, each motion readable by suitable scale and index or vernier.

AVAILABLE ACCESSORIES INCLUDE:

Auxiliary benches, cross motion carriages, narrow carriages, object holders, filar eyepiece micrometers, monochromators, etc.

Also available

Single Rod Optical Benches and Double Rod Optical Benches for applications not requiring highest precision.

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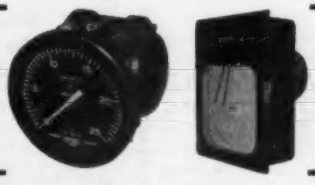
NEW BARTON FLOW METERS

MODEL 200
DIFFERENTIAL PRESSURE INDICATOR



MODEL 202
DIFFERENTIAL PRESSURE RECORDER

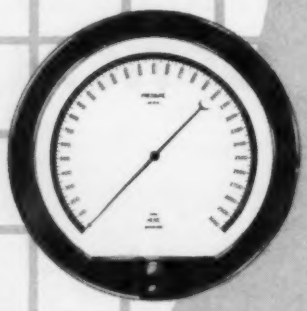
For the first time, long desired operating characteristics of the actuating element in flow meters has been achieved by Barton Instrument Company.

Stainless Steel Rupture-Proof Bellows • Torque Tube Drive • Self Venting or Draining Actuating Unit • Removable Pressure Chambers • Differential Range: 0-20 W.C. to 0-300 W.C.

Write for Preliminary Data Sheets 200-1 and 202-1

BARTON INSTRUMENT CO.
3502 UNION PACIFIC AVE., LOS ANGELES 23, CALIF.

dial scale is always concentric with the pointer travel



HEISE GAUGES

STANDARD OF THE WORLD

The scales of Heise Bourdon tube pressure gauges are absolutely concentric with the pointer rotation. Errors due to misalignment in mounting or cutting the scales are avoided since the scales are cut from their centers, and are mounted at the centers on a hollow spindle through which the pointer rotates.

Three sizes: 8½ in., 12 in., and 16 in., in ranges from 0-15 to 0-10,000 psi. Prices from $151.60 to $211.20. Write for catalog.

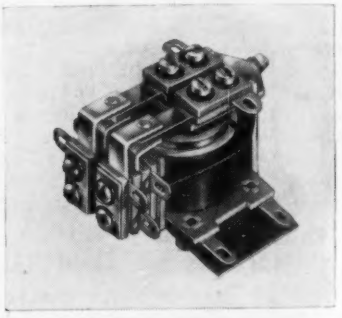
Heise Bourdon Tube Company, Inc.
Newtown, Connecticut

atmospheric conditions; is equipped with a 235-ohm continuous-duty coil and is d-p.d-t. having 0.199 in. contacts rated at 10 amps. resistive load. Capable of withstanding 10g vibration, 10g acceleration, 25g shock and protection from salt spray, sand, dust, high altitudes and high and low temperature operations. — *McCarty Co.*, 1206 *Maple Ave., Los Angeles* 15, *Calif.*

Mention No. 661 when filling out card

Midget Relay

New midget relay features extremely small size, plus exceptionally cool-running operation even under constant

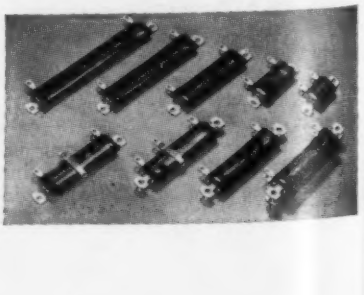


duty; is particularly adapted for use in enclosed units and shielded control panels. Over-all size of unit is 1.125 in. high, 1.375 in. wide, 1.875 in. long. Available in any combination of switches up to d-p.d-t. Standard contacts are of fine silver, rated up to 5 amps. Power consumption, 1 to 2 watts. Mounting is single center stud type. Can be supplied for use on standard voltages up to 110 volts a.c. or d.c.—*Comar Electric Co.*, 3148 *N. Washtenaw Ave., Chicago* 18, *Ill.*

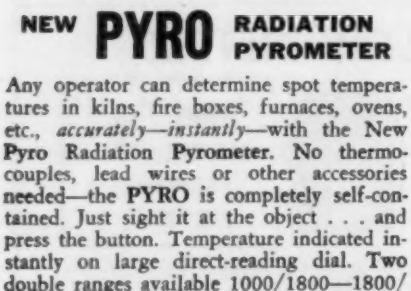
Mention No. 662 when filling out card

Thin-type Resistors

New "Thin-type" wire-wound, vitreous-enameled resistors 1 in. wide and 0.25 in. thick, provide higher wattage per unit of space and are particularly useful when space is limited. Resistor is equipped with either a single-unit mounting bracket or with a stud bracket which provides for stacking of two or more units. Resistors, with either



The *Only* Instrument You Need to Tell Spot Temperatures *Instantly!*



Just sight it . . . and press the button!

NEW PYRO RADIATION PYROMETER

Any operator can determine spot temperatures in kilns, fire boxes, furnaces, ovens, etc., *accurately—instantly*—with the New Pyro Radiation Pyrometer. No thermocouples, lead wires or other accessories needed—the PYRO is completely self-contained. Just sight it at the object . . . and press the button. Temperature indicated instantly on large direct-reading dial. Two double ranges available 1000/1800—1800/2600° and 1400/2400—2400/3600°F. *Write for FREE Catalog No. 100.*

The PYROMETER INSTRUMENT CO.
New Plant and Lab.
BERGENFIELD 4, N. J.

THIS FEATHERWEIGHT WILL

LICK SOLDERING FATIGUE!

THE NEW

HEXACON BANTAM MODEL 30H

Weight—5½ Ounces • Watts—40 or 60 • Tip Dia.—Both ⅛" and ¼" Tips Furnished with Each Iron • Price— $5.00

So light its weight is hardly noticeable. Outperforms any iron of equal size. Hatchet design makes it more comfortable and practical to use than a pencil iron. No transformer required. Write for complete catalog.

HEXACON

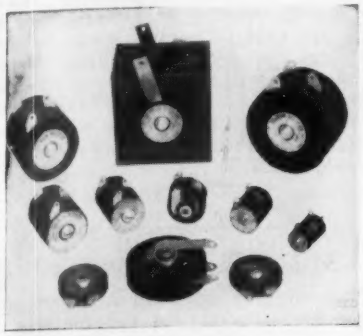
HEXACON ELECTRIC CO.
179 WEST CLAY AVE., ROSELLE PARK, N. J.

kind of bracket, are made as fixed units and as adjustable lug units—with which odd resistances can be easily obtained. Resistors vary from 1.25 in. for 30-watt size to 6 in. for 75-watt size. Five wattage sizes are available, all in a wide range of resistance values. — *Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Illinois.*

Mention No. 663 when filling out card

High-voltage Selenium Rectifiers

New high-voltage selenium rectifier cells, designed for a d-c. voltage of 24 volts per cell, with an rms. a-c. voltage



of 33 volts per cell for single-phase bridge circuits, are available in six round sizes from 1 in. to 4.375 in. diam. and in 5-in.-square and 4.25 by 6 in. sizes. Among applications are industrial supplies for electronic control, radar, and aviation actuator power supplies.—*Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Penna.*

Mention No. 664 when filling out card

Carbon Combustion Furnace

New "Model 77" carbon combustion furnace is for use at 2400 F., has unusually large (0.5 in.) silicon carbon heating electrodes and extra heavy insulation. Less heat loss, easier removal of elements and added convenience are claimed. Furnace and 1-kw. transformer are in one unit and provision is made for altering voltage in 1.6-volt steps. Operates from 220-volt single-phase 60-cycle a.c. Heating elements are located at right angles to combustion tubes.—*Laboratory Equipment Co., St. Joseph, Mich.*

Mention No. 665 when filling out card

Semi-automatic Carbon Determinator

New semi-automatic carbon determinator for analyses of carbon in steel is said to provide greater speed and accuracy because all leveling of solutions is accomplished by use of oxygen. Liquids are forced to proper level by oxygen from same source used in analysis—through "Y" tube and needle valve. Manual movement of leveling bulbs is eliminated.—*Laboratory Equipment Co., St. Joseph, Mich.*

Mention No. 666 when filling out card

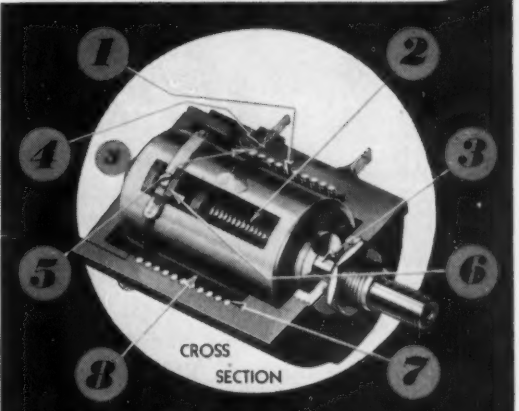
Precision Carbon Determinator

New "Model 4500" carbon determinator provides precise results in making gasometric analyses of low-carbon

MICROPOT

PRECISION TEN-TURN POTENTIOMETER

1. You get permanent accuracy because the resistance wire is locked in place. It is precision positioned and moulded integrally with the housing.
2. You get permanently accurate settings, smooth action and low uniform torque provided by the stainless steel, precision ground, double thread lead screw guiding the moving contact.
3. You get precise positioning of the moving contact because of the two bearings supporting the rotor assembly.
4. You get good rigid terminals because they are moulded integrally with the housing.
5. Terminals soldered to ends of resistance element before moulding. Entire resistance circuit is an integral part of the housing.
6. You get accurate setting and resetting due to anti-backlash spring in contact guide.
7. You get a fine resolution because of the 43½" length of resistance wire in the spiral element.
8. You get a resistance output directly proportional to shaft rotation within ±0.1% of the total resistance. Every potentiometer is automatically machine tested for linearity at 101 points.



LINEARITY ACCURACY ± 0.1%

Units for immediate shipment:
1,000 to 30,000 ohm range.
Special resistance values made to order.

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STANDARD SIGNAL GENERATOR

2 to 400 MEGACYCLES

MODULATION: Amplitude modulation is continuously variable from 0 to 30%, indicated by a meter on the panel. An internal 400 or 1000 cycle audio oscillator is provided. Modulation may also be applied from an external source. Pulse modulation may be applied to the oscillator from an external source through a special connector. Pulses of 1 microsecond can be obtained at higher carrier frequencies.

FREQUENCY ACCURACY ± .5%

OUTPUT VOLTAGE 0.1 to 100,000 microvolts

OUTPUT IMPEDANCE 50 ohms

MANUFACTURERS OF
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Pulse Generators
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Television and FM Test Equipment

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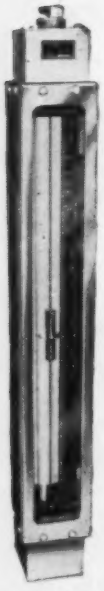

Brooks Hi-Accuracy Rotameter with 600 millimeter scale length for accurate readings.

The best answer to rotameter value

For the past three years, we have been advising you that our "Full-View" rotameter with Safety Shielding gives these advantages for flow rate measurement: (1) lower maintenance, (2) greater safety, (3) increased corrosion resistance, and (4) higher accuracy.

To date several hundred companies have found that they like our product and our way of doing business. This is the best answer we can give you to establish the validity of these claims for our rotameter. Maybe you, too, would get better performance with it.

We make all types of indicating and recording-controlling rotameters. As a starter, why not send for our Bulletin No. 20 which goes into details?

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Specify... GM

D'ARSONVAL PORTABLE

GALVANOMETERS

AND MOVEMENTS...

New!

Series 570-600
Pointer-Type
D-C Galvanometer

Here is a new addition to the line of G-M galvanometers. It is a completely assembled unit featuring an Alnico magnet for greater stability of calibration and a new high in sensitivity. Easily installed and replaced, requires only 2¾" below the mounting surface. Rugged construction throughout. Three models, with sensitivities per mm. division of .06, 0.10 and 0.20 microamps.

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pH Control

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NON-FADING GLASS COLOR STANDARDS

Pocket Comparator No. 605

Permanent reliability of Hellige Glass Color Standards, accuracy of color comparison, simplicity of technique, and compactness of the apparatus are exclusive features of Hellige Comparators.

WRITE FOR BULLETIN No. 602

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INCORPORATED

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HEADQUARTERS FOR COLORIMETRIC APPARATUS

steels, or for highly precise work with alloys of higher carbon content. Available for four burettes having ranges of 0-0.005 to 0-0.0005 percent for carbons containing up to 1.5 percent carbon. Analyses can be made in 3 to 6 minutes. Instrument features temperature-compensated burette, pump to circulate fluid for uniform temperature, and automatic leveling of solutions by means of oxygen.—*Laboratory Equipment Co., St. Joseph, Mich.*

Mention No. 667 when filling out card

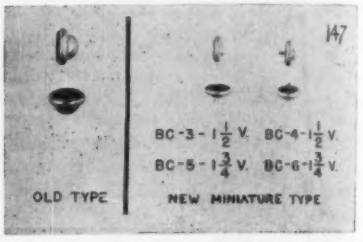
Combustion Boats

New "HF Series" of combustion boats for use in making carbon analyses of steel are said to be first ceramic type that can be used indefinitely. Maker claims they will not crack or spall as do ordinary boats and will not flake or bow at the sides as is the case with nickel boats.—*Laboratory Equipment Co., St. Joseph, Mich.*

Mention No. 668 when filling out card

Miniature Grid Bias Cell

New miniature-type grid bias cell provides a constant potential for bias of electronic tubes and circuits, where no

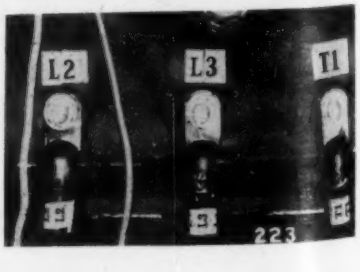


current is required of cell. Available in 1.5 and 1.75 volts. Since it is a potential device only, its emf. is lowered by even a fraction of a microampere drain; however, it is unaffected by a.c. of any frequency. At audio frequencies, cells have a non-reactive impedance of between 250 and 1,500 ohms. Satisfactory operation can be had over a range of minus 76 to plus 140 deg. F. Cell does not produce noise in high gain amplifiers. Cells are suitable for high-gain stages of voltage amplifiers, minimum bias for AVC. circuits, high-amplification triode portion of double triode-diode, etc.—*P. R. Mallory & Co., Inc., Indianapolis 6, Ind.*

Mention No. 669 when filling out card

Terminal Markers

New "Spot-It" circuit markers are said to provide positive identification of terminals, harness boards, switches and panels. Markers are quickly removable from card by means of patented "Speed-Tab" which also protects ad-



jacent unused markers. Markers are self-adhesive, applied without moistening by finger-tip pressure. Permanency is further assured by protective coating that resists dirt, grease and moisture. Markers contain only one number or letter designation to provide instant identification. Each "Spot-It" measures 0.375 in. square. Mounted on pocket-sized cards, 40 to card, markers are numbered in series 1 to 10, 1 to 20 or 1 to 40; also available in letter series from A to Z.—*Western Lithograph Co.*, 220 *Rose St.*, *Los Angeles* 54, *Calif.*

Mention No. 670 when filling out card

VHF Power Tetrode

New "4-65A" is a small VHF power tetrode tube with a maximum plate dissipation of 65 watts, intended for modu-

lator, power amplifier, and oscillator service. It can be used with full input at frequencies up to 50 Mc. and with reduced input up to 250 Mc. Features include a structure with short heavy leads, a thoriated-tungsten filament, and low interelectrode capacitances permitting operation without neutralization up to 110 Mc.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

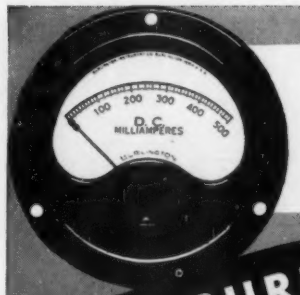
Mention No. 671 when filling out card

TV Ballast Tube

New ballast tube is hermetically sealed and filled with helium which rapidly dissipates heat to prevent over-

heating of cabinet. Tube is produced with as many as five separate controlling units and, to prevent overloading, some of 2.5-watt elements are designed to withstand 40 watts. Voltage breakdown between elements is 1300 volts d.c.—*Amperite Co., Inc.*, 561 *Broadway*, *New York* 12, *N. Y.*

Mention No. 672 when filling out card



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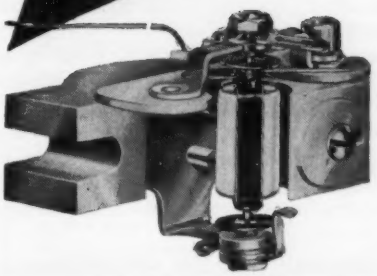

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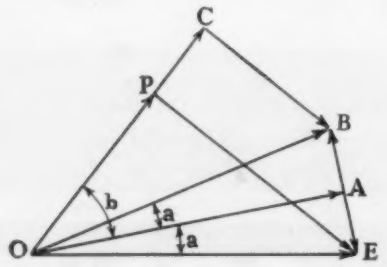
INSTRUMENTS ON THE MARCH

The Sky Compass

WASHINGTON, D. C. — In polar regions, considerable modification of conventional methods of aircraft navigation has been required because magnetic compasses and other existing instruments are inoperative. To meet this need, the National Bureau of Standards has developed a sky compass which indicates the direction of flight from which, with other data, the position of aircraft can be determined.

The sky compass is based on the investigations made by the late Dr. A. H. Pfund of Johns Hopkins University and



Optical operation of Pfund Sky Compass on plant polarized light.

Section normal to ray of incident light.

OE Amplitude and direction of polarization of incident light.

OP Amplitude and direction of polarization of light transmitted through polaroid only.

OA Principal direction through half-wave plate (cellophane).

OB Amplitude and direction of polarization of light after passing through half-wave plate.

OC amplitude and direction of polarization of light transmitted through half-wave plate and polaroid.

is an outgrowth of his twilight sextant. Proposed initially by Cmdr. T. S. Davies, USN, the instrument was developed principally by F. Cordero, Dr. D. P. Johnson, and S. H. J. Womack of the NBS, at the request of the Navy's Bureau of Aeronautics.

The Pfund sky compass (not to be confused with the sun compass) operates on the principle that the light of the sky during the day is partly plane polarized, the polarization being a maximum at right angles to the incident beam from the sun. The plane of polarization at any point in the sky thus contains both the observer and the sun. Establishment of this plane also gives direction since it points to (or away) from the sun.

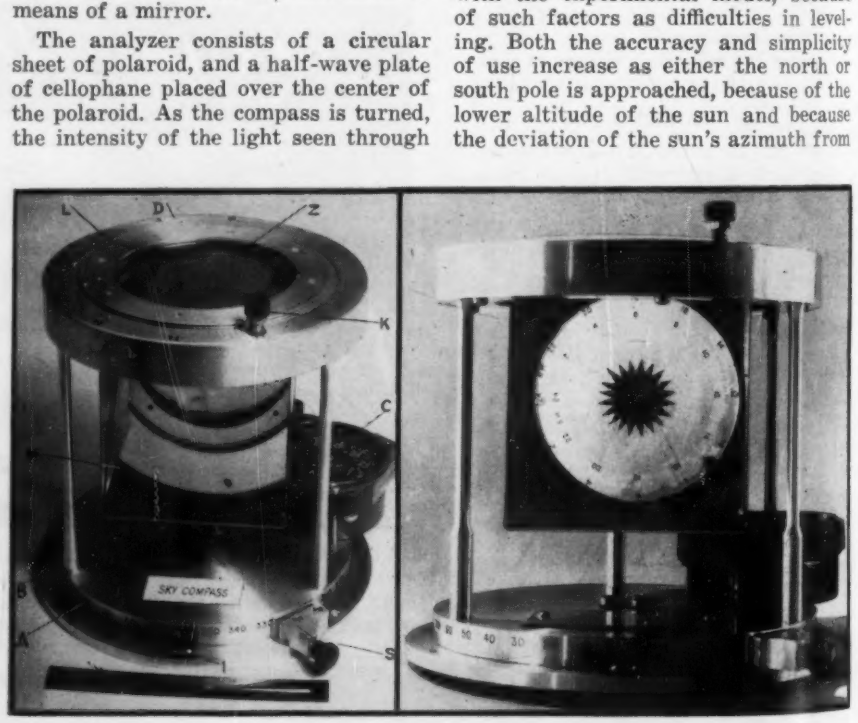
The principal advantage of the sky compass over the sun compass (which measures the direction of the sun directly) is its use during twilight, and when the sun is several degrees below the horizon, as well as when the region of the sky containing the sun is overcast, so long as there is a clear patch of sky overhead. The sky compass is thus of particular value when the sun compass and the sextant are not usable, after sundown before evening stars appear, and after morning stars disappear but before sunrise. Since the extent of polarization of the sky's light is greatest at right angles to the incident beam of sunlight, the compass is most accurate in the polar regions, where it is also most useful, because of the long duration of twilight and the weakness and inaccuracy of the magnetic compass at high latitudes.

Essentially, the sky compass consists of an analyzer for determining the plane of polarization of the light, an azimuth circle on which the sun's computed azimuth can be set, and a clock which drives a chosen reference line in synchronization with the sun's apparent motion, that is, one revolution in 24 hours. For convenience in observing a portion of the sky around the zenith through the analyzer, the analyzed beam is turned from vertical to horizontal by means of a mirror.

The analyzer consists of a circular sheet of polaroid, and a half-wave plate of cellophane placed over the center of the polaroid. As the compass is turned, the intensity of the light seen through the polaroid will change. If the light source is completely plane polarized, the intensity variation will include two maxima and two minima (zero intensity) in one complete revolution, the maxima occurring in the plane of polarization, the minima at right angles to it.

To facilitate accurate judgment, the half-wave plate is used. This in effect rotates the plane of polarization of the light by an angle which depends on the orientation of the plate's "optical axis" to the plane of polarization. Using this effect, together with that of the polaroid, a setting may be made by matching the intensities rather than by estimating maximum intensity. The light which has passed through the half-wave plate appears in the form of a star at the center of the field of view of the instrument, on the background of the light which has passed only through the polaroid. At four points in a complete revolution, the intensity in the two light paths will be the same, and the field will blend into a homogeneous whole. Two of these matches (at right angles to the plane of polarization) will be "dark," the other two will be "light," so that a light match determines the plane including the sun, and it is only necessary to be able to distinguish by direct observation of the sky the general directions "toward" and "away from" the sun.

The sensitivity of the instrument depends on the angle between the optical axis of the half-wave plate and that of the polaroid. An accuracy of 1 degree may be obtained in measuring the sun's direction. On an airplane, the accuracy is expected to be somewhat less than with the experimental model, because of such factors as difficulties in leveling. Both the accuracy and simplicity of use increase as either the north or south pole is approached, because of the lower altitude of the sun and because the deviation of the sun's azimuth from



(Left) Principal parts of the Pfund sky compass are the azimuth scale, A; the base, B; the clock, C, for rotating the polaroid analyzer Z with the sun; a time scale, D; indices I and L for the azimuth and clock scales respectively; a clamp S to maintain the azimuth setting, and a knob K for rotating viewing mirror M. (Right) A view through the mirror of the analyzing polaroid unit of the sky compass. To obtain the heading indicated on the azimuth scale, the instrument as a whole must be rotated to equalize the intensities of the transmitted polarized lights through the central star and background.

that corresponding to local apparent time is negligible. The compass may be read when the sun is as much as 7 degrees below the horizon, but accuracy drops quickly when clouds obscure the zenith.

Jet-engine Research Aided by Electron Diffraction

SCHENECTADY, N. Y.—An instrument which uses a stream of electrons to study a layer of metal less than a quarter-millionth of an inch thick is aiding engineers of the National Advisory Committee for Aeronautics in their search for better metals and lubricants for jet engines, it was announced by General Electric's Special Products Division.

Developed by the company's General Engineering and Consulting Laboratory, the electron diffraction instrument is used in determining the effects of various lubricants and in friction studies of polished metal engine parts. Engineers explained that ordinary lubricants are not adaptable to high speeds and temperatures inherent in jet engine operation, and that new lubricants, therefore, must be developed.

Another NACA group has been using an electron diffraction instrument in attempts to improve high-temperature metals.

With the instrument, engineers can detect in a few seconds natural films which emanate from the steel itself and chemical changes produced on the surfaces by lubricants. These chemical changes, they said, are not visible under a miscroscope, and formerly could not be detected with such equipment.

By subjecting the metal parts to temperatures and speeds which simulate actual flight conditions, and then examining the parts with the instrument, the researchers have been able to identify specific film materials normally deposited on the bearings when the engine operates. Used to study parts which have been worn by tests, the device helps engineers discover and minimize the causes of friction.

In operation of the instrument, electrons emitted by a white-hot tungsten filament are focused into a beam by a magnetic lens. For one type of work, the beam then is passed through a two-microinch-thick section of metal and produces an image on a fluorescent screen or on a photographic film. For another type of work, the beam is directed to a metal surface at an angle. Tiny projections on the surface diffract the electrons and form the image. The image produced is different for each material, and both the surface conditions and crystal arrangement of the molecules of metal can readily be determined.

Since electrons will not pass through air freely, the chamber in which they travel is evacuated to a pressure of approximately one eight-millionth of an atmosphere.

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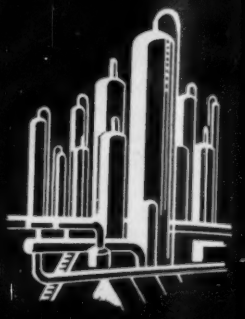

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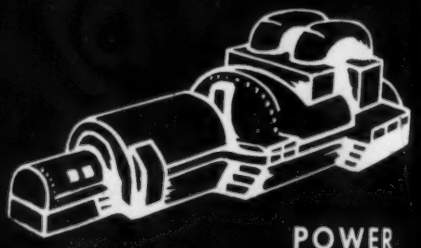
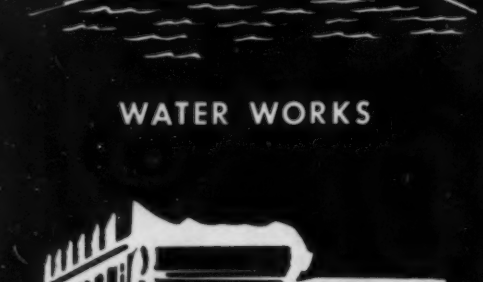


POWER



WATER WORKS

PAPER

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Vol. 4 | JUNE 1949 | No. 6

General News

St. Louis Conference and Exhibit

On March 3rd, the St. Louis Conference and Exhibit Committee met with Dick Rimbach at the Statler Hotel. The Committee is made up as follows: P. R. Watson, Mullins Non-Ferrous Castings Corp., General Chairman; W. E. (Bill) Boyle, Shell Oil Co., Woodriver Refinery, Vice Chairman; Carl E. Werstler, Socony Vacuum Oil Co., Chairman, Allocations Committee; H. F. (Hans) Freeman, Economy Equipment Co., Chairman, Entertainment Committee; James M. (Jim) Mozley, Jr., Dept. Chemical Engineering Washington University, Chairman, Educational Committee; Mayer B. Roberts, Brown Instrument Co., Chairman, Meeting Properties Committee; E. H. (Ed) Ronsick, Economy Equipment Co., Chairman, Reception and Registration Committee; J. T. McFarland, Ragan Corp., Vice-chairman, Reception and Registration Committee; Mr. H. B. Freeman, Chairman, Ladies Committee; H. T. (Harry) Weeks, Chairman, Special Exhibits Committee; L. C. Lodge, Chairman, Committee on Cooperating Societies, C. K. Williams & Co.; Orland G. Forcade, Shell Oil Co., Woodriver Refinery, Chairman, Publicity Committee; W. G. (Bill) Lee, Titanium Division, National Lead Co., Secretary, St. Louis Section, ISA; Hart V. Fisher, Monsanto Chemical Co., Chairman, St. Louis Section, ISA.

The St. Louis Convention Committee is hard at work on plans for the Annual meeting. Preliminary plans indicate that the St. Louis Convention will have many unusually interesting events. The Committee on Cooperating Societies under the Chairmanship of Landon Lodge, reported that the following will cooperate in "putting over" the St. Louis Meeting: Industrial Instruments and Regulators Division, American Society of Mechanical Engineers; Instruments and Measurements Committee, American Institute of Electrical Engineers; American Institute of Physics, Scientific Apparatus Makers Association; National Telemetering Forum; and possibly the Institute of Radio Engineers; and the American Institute of Chemical Engineers.

Carl Werstler, Chairman of the Allocations Committee, reported that his committee had allocated 140 booths at the Exhibit, to 91 companies, which were at the Philadelphia Show. The Philadelphia Exhibitors, at the request of the Exhibitors' Advisory Committee, were granted a 30 day option on the Exhibit booths at St. Louis before the space was thrown open for general sale. In the 1948 Exhibit Space sale—90 booths were sold in the first 30 days. In the same period of time—150 booths were sold in St. Louis. At present, only 26 booths remain to be sold.

Possible New Sections

At present we have 44 Sections with a total membership of 3908 on May 1, 1949. Charter applications are in, but not acted upon, from groups in New Mexico and Baton Rouge.

The Secretary met with a group at Denver on October 18, 1948, which plans to organize a section.

On April 28, 1949, the Secretary met with a group in Columbus which was called together by the following Sponsoring Committee: Mr. Orval Linebrink, Chairman, Battelle Institute; Mr. George Wright, Federal Glass Co. (Member ISA); Mr. Eugene Pontius, Chemical Engineering Dept., O.S.U.; Mr. C. F. Lucks, Battelle Institute (Member ISA); Mr. M. L. Cleaton, Foxboro Co., (Member ISA).

About 100 men were present. The meeting empowered the Sponsoring Committee to call another meeting in May. About half of those present signified their intention to join the ISA.

New York Section Plans 1950 Conference

The New York Section is again planning to sponsor a mid-winter conference in January 1950. The subject of this third annual conference will be "Temperature Measurements". Professor Kayan will be in charge of the Friday sessions when techincal papers will be presented. All day Saturday, instruction will be given by various manufacturers on servicing of temperature measuring instruments. Mr. C. J. Zeller will be in charge. Vice-president, Charles E. Haggerty will arrange the banquet.

Section president, E. Ralph Manning has appointed the following Committee chairmen for the 1950 Conference: A. K. Joecks, Chairman; Prof. C. F. Kayan, Chairman, Friday Session; R. R. Batcher, Vice-chairman, Friday Session; C. J. Zeller, Chairman, Saturday Session; Norman J. Cherry, Secretary; G. C. Kauer, Jr., Finance; John E. Warren, Facilities.

Section News

ARUBA

Henry M. Schmitt talked on "New Developments in Pressure, Level and Temperature Measurement" at a special meeting on Mar. 29th.

On April 5th, T. W. Macie, International Business Machines, spoke on "Controls and Control Systems in the Modern Business Machine". It is planned to follow this talk with a field trip to observe these machines in operation.

The Curacao Sub-section, in February, enjoyed a field trip to a submarine in the Marine Base at Parera. Planned for the future is a series on "Automatic Control Systems" by M. E. Wieringa, who is doing research on control applications with C.P.I.M. in Curacao.

BOSTON

The seventh meeting of the season was held at the Esso Refinery, Everett, Mass., on April 27th. Dinner was served at 6:30 P.M. to fifty-four members. The after dinner speaker was Mr. Francis G. Tatnall whose subject was "Industrial Application of Strain Gages." Mr. Tatnall has been manager of testing research for the Baldwin Locomotive Works since 1943. His talk was very interesting.

Also there was the election of the section officers for the 1949-50 season. The officers elected were: President, Herbert Cole; Treasurer, Charles Peirce; Secretary, C. J. Nazzar; Program Committee, Herbert Meyer; Social Committee, Stephen Lord; Membership Committee, Zeke Petty; Representative to the ISA, Nelson Gildersleeve.

On May 25th there will be a Social Party and Dinner at the Hotel Buckminster, Boston, this will be the last meeting of the season.

J. H. Condon,
Corr.

CALIFORNIA

The May 3rd meeting of the California Section was held at Roger Young Auditorium in Los Angeles. Mr. Claude B. Nolte, Manager of Sales for the Barton Instrument Co. of Los Angeles, presented a splendidly prepared talk on the "History of Bellows Actuated Flowmeters". Mr. Nolte illustrated his talk with slides, concluding with a demonstration employing rupture-proof bellows for differential pressure measurements, and a display of Barton Instruments and equipment.

Our next meeting will be held on June 7th at the University Club in Pasadena, with two speakers scheduled. Mr. Norman Reuel of North American Aviation's Aerophysics Laboratory will present a talk on "Instrumentation problems in the Synchronization of a Liquid Propellant Rocket Power Plant," illustrated with slides. Mr. Tom Wiancko of Wiancko Engineering Co. will talk on "Instrumentation for Static Testing of Rocket Power Plants," and present a demonstration of equipment.

Chris Wagner,
Corr.

CENTRAL INDIANA

The May 4th meeting was held at the Goethe Link Observatory near Booklyn, Indiana. A large attendance of members and guests heard Dr. John B. Irwin discuss "Measurements in Astronomy". Dr. James Cuffey demonstrated the 36" reflector, which was trained on Saturn. Dr. Frank K. Edmundson of Indiana University also talked on the 5" refractor and the use of photoelectric equipment being developed at the Observatory.

The June 7th meeting will be held at 8:30 DST at Rose Poly in Terre Haute. It will be a joint meeting with the National Association of Power Engineers. The speaker will be C. W. Marks of the Republic Flow Meter Co., who will talk on "Boiler Combustion Control".

E.E. Taylor,
Corr.

CHICAGO

The speaker on April 4th, Mr. J. M. (Dutch) Brashear, Ass't. Superintendent #2 Open Hearth Inland Steel Co., discussed "Applied Instrument and Control Maintenance in the Steel Plant." He brought out the fact that the Open Hearth has presented one of the greatest challenges to fuel and maintenance engineers in steel-making history, and that the Open Hearth offers a field for equipment which is different from almost any other.

The economy of efficient instrument maintenance is best studied, said Mr. Brashear, not so much from the first cost of the unit, nor from its cost of upkeep, but rather from its relative value to the unit or process.

Mr. Brashear discussed some of the major points of his company's "instrument man" training program and suggested that possibly the maintenance division should assume the job of training the operators in how to handle the instruments in their shops.

R. R. Proctor,
Corr.

GULF COAST

The Section held its regular monthly meeting March 29, 1949, at Lamar College, Beaumont, Texas. Mr. George Horton, chairman,

introduced Mr. J. A. Pellettree, of the Gulf Oil Corp., Pittsburgh, Pa., whose subject was "The Use of Interconnected Control Instrumentation for Offsetting Unfavorable System Characteristics."

The meeting was adjourned after Mr. Pellettree answered many questions concerning process troubles and poor installations of instruments.

J. W. RUTLEDGE,
Corr.

KANSAS CITY

The Section held its regular meeting on Tuesday, April 26th at the Blue Bird Cafeteria, 3215 Troost Avenue. Guest speaker was Louis V. Hickman of Westcott & Greis, Inc., Dallas, Texas, who presented an illustrated talk on Pneumatic transmission of process variables. The members were informed of the two summer tours which are now being arranged. The June tour will be at the Corn Products Refining Co., North Kansas City, Missouri and the July tour will be through the Standard Oil Refinery at Sugar Creek.

W. A. REICHOW,
Corr.

MONTREAL

The Montreal Section held an annual election of officers at its meeting on April 25th. The officers elected for the coming year are: President, F. S. McCarthy; Vice-President, J. H. Bolton; Secretary-Treasurer, L. J. Mizuhara; Assistant Secretary, J. E. Oles: Directors, R. M. Brown and two others yet to be elected from a nomination slate drawn up at the meeting.

The speakers for the evening, J. V. Quinn and G. A. Rice both of Canadian Industries, Limited, Montreal, provided a discussion of the Instrumentation design for a chemical process as it would be prepared jointly by a process and instrumental engineer. The flowsheet for a sulphur dioxide liquefaction plant was used for the demonstration.

At the May meeting of the section, following brief reports from the various committees, a stag gathering will be held in place of the ladies night previously planned. A hall and grounds for the occasion have been generously provided by Peacock Brothers Ltd. at Ville LaSalle.

G. A. RICE,
Corr.

NEW YORK

The sixty-sixth meeting was held on the twenty-fifth of April when a visit was made to the Columbia University Nevis Cyclotron Laboratory, located at Ardsley-on-Hudson, New York. Well over a hundred members and guests made the trip, arrangements for which were made by our National President, Professor Carl F. Kayan, with Dr. John R. Dunning. Mr. M. W. Johnson is Resident Manager of the Laboratory, and Mr. Warren Goddell was Host and Guide.

Mr. Goodell gave a very interesting talk on the construction and operation of the Cyclotron. This is one huge magnet weighing around 2300 tons, of soft iron (carbon content less than 1 percent) which will develop 400 million electron volts with an input of 600 kilowatts. Water pumped from the Hudson River is used for cooling the coils. This Cyclatron is the largest of its kind in the world at present, although larger ones are anticipated in the future.

Our May meeting will be held on May 23rd at the auditorium of the Consolidated Edison Co., of New York, Inc., 4 Irving Place, New York City. This will be a joint meeting with the Radio Club of America. Dr. E. Weber of Brooklyn Polytechnic Institute will give a paper on "Magnetic Amplifiers". This is a subject that has been discussed quite widely, but there are a number of people who are not as familiar with it as they probably should be. We think it will be a good opportunity for instrument men to obtain first-hand knowledge, as no doubt they have many cases where this might be applied.

Word has just come to us that our Past National President and Past New York Section President, Dr. Owen Fairchild, is in a New York hospital for observation, and last reports were that he is getting along satisfactorily. We will report further on this as soon as more details are available.

H. KALBFLEISCH,
Corr.

NIAGARA FRONTIER

The regular meeting of the Niagara Frontier Section was held on April 25th. About 25 members attended a dinner at 6:30 PM in the Institute's dining room, and a total of about 35 were present when the meeting convened at 8:00 PM.

This meeting included election of officers, and the following were elected for the coming year: President, Joseph Hildyard, Hooker Electrochemical Co.; 1st Vice Pres., J. A. Ekhardt, Wickwire Spencer Steel Co.; 2nd Vice Pres., John Bugman, Bethlehem Steel Co.; Treasurer, George Kellner, Linde Air Products Corp.; Secretary, E. J. Hayter, National Aniline Co.

The speaker of the evening was Mr. Lyle E. Eige of Fisher Governor Co., who talked on "Plain Facts About Diaphragm Motor Valves". Mr. Eige gave a very interesting talk on the characteristics of various types of inner valves and diaphragm topworks, and included data on the limitations of diaphragm valves under certain conditions of high pressure drop. At the May 23rd meeting the new officers will be installed and a talk will be given by Mr. E. B. Bevelheimer on the subject "Instruments as Tools for Combustion Research."

W. J. SOMMERS,
Corr.

NORTH TEXAS

We had an exceptionally interesting meeting on April 26th when Mr. E. F. Upton, Supervisor of Standard Products Application Department of Minneapolis-Honeywell Regulator Company gave a very informative as well as interestingly presented paper on "Pyrometric Principles and Electronic Measurement." The group was so interested in the subject that Mr. Upton was kept busy for 45 minutes after his presentation answering questions. We had six visitors who came 165 miles to hear this paper.

F. ZAPFFE,
Sec-y.

OAK RIDGE

The Section met April 6th at The Oak Terrace, Oak Ridge, Tenn. This was the first regular meeting since the Area Gates were removed. We discussed the possibility of creating an interest in our society among those interested in the field of Instrumentation and living in near by towns and cities. We are extending an invitation to this group, through the Journal, to visit our Section to learn more about the many benefits which can be derived in becoming affiliated with the ISA. We meet at the above location on the first Wednesday of each month. Those who read this will do us and their friends a favor if they will pass this information along to those who have an interest in the Instrument Field. Send us a card or letter and we will gladly send you a meeting announcement which always includes the speakers name, his business affiliations and subject which he will discuss.

We had a good attendance at the dinner and regular business meeting. Mr. Pond of the Taylor Inst. Co., was on hand with his 1400 pounds of special equipment and ready to start relating his famous "Fairy Tale". We conducted a brief business meeting during which Mr. S. A. Hluchan won the ISA pin.

JOHN H. CLARK,
Sec'y.

PHILADELPHIA

The regular meeting, held on April 20th at Bellevue-Stratford Hotel, had as the speaker, Mr. O. B. Whitaker, Sperry Gyroscope Co., Inc., who gave an illustrated lecture on "Marine Instrumentation." Mr. Whitaker began with such crude devices as the compass, astrolabe and lead line, and showed the development of today's instrumentation through the gyroscope to radar and loran.

With instruments determining the ship's position, the water under it, the objects ahead, and true course, the men who go down to the sea in ships have ample reason to be thankful for these developments. One hundred persons attended the meeting.

W. E. HARRISON,
Corr.

PITTSBURGH

Announcement of the newly elected officers of the Pittsburgh section was made at the April 25th meeting. The elections committee reported as follows: President, L. M. Susany, Carnegie Institute; Vice Pres. R. R. Webster, J&L Research Labs.; Secretary, Miss Louise Suckfield, Gulf Research; Treasurer Clark Fry, Westinghouse Elec. Corp.; Executive Committee: Harold G. Jones, H. G. Jones Co., L. G. Klingenberg, Blaw-Knox, John W. Wagner, Bacharach Inst. Co.

The technical paper was presented by Dr. E. L. Harder of Westinghouse Electric Corp. He spoke on his company's "Analog Computer," which has thus far been used to solve problems in dynamic electrical and mechanical systems. To use this new tool, an electrical analog of the system being studied is built, and impressed with a change similar to that of the system. The analog behavior is observed on electrical instruments or a cathrode ray oscilloscope. In Dr. Harder's opinion, the field of application for analog computors is much broader than for digital computors.

M. M. FROMM,
Corr.

ROCHESTER

Two motion pictures supplied by the Westinghouse Electric and Mfg. Co., through their representative, Mr. C. F. Harris, entitled "Adventures in Research" and "Induction and Dielectric Heating" were shown at the April 26th meeting. The remainder of the evening was spent as a social function with free refreshments for the 58 members and guests that were present.

EINAR W. JENSEN,
Corr.

SAINT LOUIS

The April 6th regular meeting was addressed by Mr. J. T. McFarland, District Manager of Hagan Corporation. Mr McFarland described the two types of ring balance meters, namely the weight loaded ring, and the spring loaded ring, the first having a square root chart, while the latter has a straight line chart.

The motion of this type of element at small flows is very large in comparison with other types, having 45 per cent of movement over 30 per cent of flow, giving superior accuracy at small flows. The integrator used appears to be rugged and positive, with simple adjustment. Dual rings may be used in one case for steam-flow-air-flow applications and the like. Temperature and pressure compensators can be incorporated in the meter. A report was made by Mr. Phil Watson, Chairman of 1949 Conference and Exhibit, on progress being made toward making this year's show the biggest and best held by the ISA.

H. E. ZEFFREN,
Corr.

WASHINGTON

The April meeting was held in the PEPCO building on Monday, April 18, 1949, and was attended by over 150 people. Mr. F. G. Nesbitt of the Sperry Gyroscope Co., Great Neck, New York delivered a lecture on the "Gyropilot" and "the Zero Reader." He described the flight results and illustrated with slides and pictures the performance of the "Zero Reader." Low ceiling approaches were shown where the "Gyropilot" was being used to effect safe landings.

RAYMOND E. MILLER,
Corr.

SEE ARTICLE ON NEXT PAGE

THE AUTHORS

W. E. Boyle

P. R. Hoyt

Mr. Boyle has been an instrument engineer for many years having handled instrumentation of utility and mining properties for Byrne Electric Co., Denver. He established process instrumentation and instrument departments for Consolidated Aircraft Co. He joined Shell Oil Co., Inc. in 1940 as Instrument Engineer.

Mr. Hoyt, now with Shell Development Co., has been associated with Shell since 1934 as operator, in charge of instrument maintenance, and as instrument engineer. He has been responsible for the selection and installation of instrumentation systems for 25 new process units, including 2 catalytic cracking units and combustion control system for 6 high pressure steam generators.

Experimental Application of Combustion Controls To a Process Heater*

By W. E. BOYLE and PAUL R. HOYT

Introduction

We are all aware that during the past few years there has been an increasing fuel oil shortage. Last winter this alarming situation was particularly brought home to us, as domestic users, when it was necessary in many localities to resort to emergency measures in order to assure sufficient distribution to meet minimum fuel requirements. Although fuel manufacturing and supply facilities are being rapidly expanded by the oil industry, it does not appear that adequate supplies will be available in the immediate future.

Less apparent to many of us perhaps, but of more importance to our economy, is the effect of the fuel oil and fuel gas shortage on industrial users. Nearly every industry in some phase of its operation is dependent upon fuel as a source of heat energy for steam generation, process operation, and the many other uses with which we are all familiar. It is safe to say that one of the prime requisites that enables industry to produce at its maximum capacity is the availability of fuel. Availability of fuel is not enough, however, in industries where heat requirements are considerable and fuel represents one of the major operating costs. Not only must the cost of the fuel itself be considered, but the type of fuel as well. The selection of a fuel type is very important to economy since it determines, in a sense, the cost of handling facilities, burners, and combustion chambers required. Furthermore, the fuel characteristics must be such that a high degree of combustion efficiency can be maintained under continuously varying heat loads with a minimum amount of automatic control equipment.

Causes of Fuel Shortage

Petroleum products, whether in the form of gas or liquid, are ideal fuels for most industries since (1) the cost is comparable to other types of available fuel, (2) due to its fluid state, both handling facilities and burner and fire box design are simplified resulting in lower initial cost, and (3) control systems with comparatively simple mechanism can be used to obtain optimum combustion efficiency. Due to these advantages, an increasing number of industries in recent years have turned to petroleum products as a source of fuel.

With the enormous expansion of operating capacity of most industries during the past several years and with the development of new industries, the demand for fuel has increased proportionately. This increased demand, however, is not alone responsible for the critical fuel shortage. Another factor is the development of new processes and improved operating techniques in our oil refineries which convert waste material formerly used for fuel into high quality motor fuels and the other salable petroleum products. In addition to this, our research departments have developed chemical processes which also utilize this waste in their production.

Fuel Conservation Program

Thus, with the demand for fuel increasing, and the available fuel stock diminishing, it is not difficult to see why a shortage of fuel has developed. Conservation of fuel is therefore of major interest to most industries today and methods for improving combustion efficiency are receiving more and more attention.

Contrary to what might be expected, the need for fuel conservation in the petroleum industry is even more pronounced than in many other industries which have operated for years with fuel as a purchased utility. The reasons for this are quite apparent when one is familiar with the enormous heat energy requirements of most processes in the oil refinery realizes that up until recent years all of the heat was supplied from the burning of waste products in the form of heavy residue oils and gaseous materials. In fact, until just recently there was a surplus of waste products which were disposed of by burning in ponds and flares. The picture is reversed today. Every means for conserving fuel is being investigated. Many refineries are burning coal in their boiler furnaces although this requires a larger initial investment in equipment.

In establishing a conservation program, particular attention is being given to the design and operation of process heaters. In the past these heaters were designed by the manufacturers with little thought given to combustion efficiency, but rather to such factor as operating convenience, ease of cleaning and replacing tubes, and low initial cost. In operation, every effort was directed toward maintaining the outlet temperature of the oil at a constant value with combustion efficiency being of secondary importance. The operator responsible for furnace operation, in many instances, was assigned other duties on the process.

In contrast, the maintenance of efficient combustion control under all load conditions has been the first design consideration of steam generator manufacturers. Elaborate automatic control systems have been developed not only to guarantee optimum combustion for all loads, but also to assure correct proportioning of combustion air flow and fuel flow during load changes. In operation, a fireman usually devotes his full time to observing combustion conditions.

Improved Combustion Efficiency Effects Fuel Savings

Several years ago, the Wood River Refinery of the Shell Oil Company, Incorporated, started a program of fuel conservation. One phase of this program was an investigation of methods to improve combustion efficiency in existing process heaters. It was found that in many instances combustion efficiency could be improved vastly without having to make major alterations to the burners, fire boxes, or fuel systems. The basis for improvement lay in using the flue gas analysis and observing furnace temperatures and pressures as guides for obtaining optimum combustion efficiency and balancing the heat load.

To realize significant fuel savings, however, continuous attention would be required. This could be accomplished only by increasing personnel or using suitable automatic combustion control equipment. The former was initially tried but found to be impractical. In the first place, with the equipment available, technical personnel were required to take and analyze the data in order to make the corrective adjustments. In most cases, it was found that load changes occur frequently and in order to assure sufficient combustion air for peak loads it was necessary to adjust air flow for these conditions. Obviously this resulted in excessive stack heat losses during normal operation, thereby limiting potential savings which could be effected by continuously adjusting air to suit fuel demand. It was apparent, therefore, that automatic controls would be required, preferably with records of the important variables to be

*Presented at the Third Annual Conference of the Instrument Society of America, Sept. 13-17, 1948, Philadelphia, Pa.

Note:—Statements and opinions advanced in papers are to be understood as individual expressions of the authors and not those of the Society.

controlled and easily read indications of other conditions to enable the operator to analyze quickly operation of the furnace as a whole and make any necessary manual adjustments on individual components.

Application of Automatic Controls to Process Heaters Studied

A survey was made of equipment available and of methods tried in the past for applying automatic combustion controls to similar types of furnaces in process service. Results of this survey indicated that it was impractical to design a control system applicable to refinery process heaters in general. Due to the variety of heater designs, arrangements of burners, and combustion air adjustments, it would be necessary to design a control system for each individual furnace. Despite this fact, it did seem reasonable that basic principles of combustion control methods could be applied to many heaters. In order to establish these principles, from a practical standpoint, and to evaluate manufacturer's standard equipment, it was decided to make an experimental installation. For this purpose a heater was selected in a heat medium service where the only operating requirement is to release heat in an amount and at a rate to elevate and maintain the temperature of flowing oil at a constant predetermined value. The oil flow is at a constant rate and does not vaporize or change state with temperature change.

This heater is a conventional radiant type, two cell, natural draft furnace. Fired by 14 burners from each side wall, it is designed for 50,700,000 BTU per hour heat release, and is illustrated by

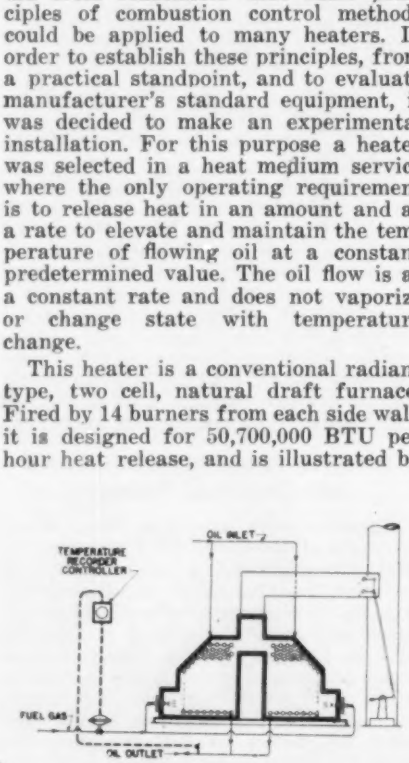

Fig. 1.

a schematic cross section view in Fig. 1. The burners are of the conventional combination fuel gas, fuel oil-steam atomizing type. Primary air is adjusted manually on each individual burner by louvres, while furnace draft is controlled by a multiple vane type stack damper. Fuel oil and atomizing steam are also manunally adjusted by hand valves on individual burners. Combustion gases leaving the radiant sections pass through the convection sections into a common flue gas duct and out the stack. The oil enters the tubes in two parallel streams from a common header, flows through the convection tubes, roof tubes, floor tubes, and then out to a common header again.

In the original arrangement, the outlet oil temperature was automatically controlled by a pyrometer type instrument with a primary element located in the oil outlet line. The controller output air pressure loaded a pressure balanced type diaphragm valve in the fuel

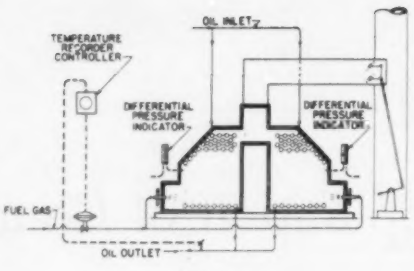

Fig. 2.

gas line. In order to conserve fuel gas, it is normal practice to base fire manually to supply about 80% of the normal heat load demand. Since heat load fluctuations do not exceed 20%, constant outlet temperature is maintained by the temperature controller operating the diaphragm valve in the fuel gas line.

With these operating conditions in mind, let us summarize some of the requisites considered desirable from an operating and maintenance point of view which influenced the design of the system and the types of equipment selected.

1. Sufficient continuous records and indications of the variables which affect combustions, thereby enabling the operator to analyze quickly furnace operation at all times.
2. For operator's convenience, central location of the instruments indicating, recording, and controlling these variables, preferably adjacent to the process instruments.
3. Design the system for simplicity with as few components and interconnections as possible to avoid specialized training of operators and instrument men.
4. Where possible, use components of standard design preferably furnished by a manufacturer who is thoroughly familiar with combustion control systems and with the design and operating requirements of process heaters.
5. Initial cost of the installation should be such as to permit a reasonable payout time, based on fuel savings effected by improved combustion efficiency.
6. Design must conform to safe operating practices.
7. System must be stable and should not influence or upset process operation.

Development of System for Experimental Installation

One of the fundamental requirements of combustion control is the regulation of fuel and combustion air flow in the correct ratio to give optimum combustion. As an operating guide it is, therefore, desirable to measure and indicate or record the instantaneous flow rates of these two variables. The measuring of fuel flow offered no problem as there already were existing meters on both the fuel oil and fuel gas lines. Means for actual measurement of air flow, however, were not immediately apparent. The conventional methods used in many boiler furnaces provided with forced air systems obviously could not be applied on natural draft furnaces of this type. It was decided, therefore, to use the fire box pressure as an indication of rate of air flow. If we consider the burner air ports as a fixed orifice or restriction, then the differential pressure between fire box and atmospheric pressure is related to the rate of air flow through the ports.

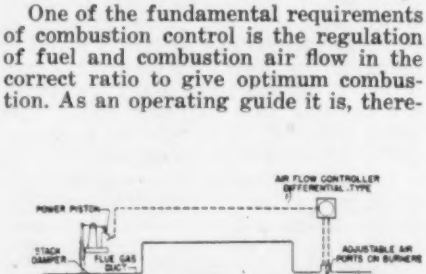

Fig. 3. Equivalent Air Flow Control System.

For measuring this differential, two slack diaphragm type differential indicators were provided one for each fire box and connected as shown in Fig. 2. In order to assure measurement of actual differential pressure across the burner ports, the high pressure lead from the differential unit was located with its open end adjacent to and in the same plane as the atmospheric side of the burner ports. The low pressure lead terminated in the fire box. These instruments not only provided a means for detecting air flow changes, but also served as a guide for equalizing both cells of the furnace.

Let us assume that the individual burner ports are adjusted at some optimum fixed opening. By varying the opening of the uptake draft damper, a change of furnace pressure or differential pressure across the ports will produce a related change in the rate of air flow. In order to have automatic control, it is a simple matter to connect

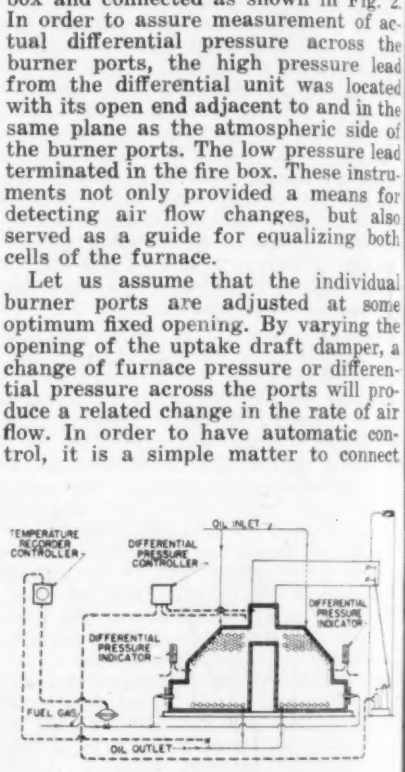

Fig. 4.

the low pressure side of the measuring element of a differential pressure controller to the furnace and have the controller output pressure position the damper. This is equivalent to a conventional differential type flow control system (see Fig. 3) and an actual installation was made as shown in Fig. 4. The differential element of the instrument used was of the same type as the indicators previously mentioned.

We now have provided means for measuring and controlling the total combustion air flow only for a fixed heat load. Fuel flow, however, is automatically varied by the temperature controller to balance fluctuating heat load demands. It is desirable to vary air flow simultaneously with fuel flow. Since the temperature controller output pressure is proportional to heat load demand, it was utilized for this purpose and connected to the air flow controller through an adjustable ratio mechanism. For a given ratio adjustment, this pressure

sets up a proportional demand for air flow which is satisfied only when balance is restored by the flow controller. Thus, we have a method for automatically changing the rate of air flow in a predetermined ratio with fuel flow changes demanded by the temperature controller.

It may be apparent to some that the system developed thus far has one major objectionable feature which limits its use as a completely automatic control system. The ratio of fuel flow to air flow should be a fixed ratio regardless of heat load. Due to the principles on which the fuel flow and air flow are measured and the effective characteristics of the controlling elements, this condition cannot be maintained unless the ratio mechanism is manually readjusted as the load changes. In order to maintain automatically the desired ratio over the complete operating range, specially constructed compensating mechanisms would be required. A more desirable method appeared to be the use of a device for continuously measuring combustion efficiency as a means of furnishing final corrective action.

As is well known, the most economical combustion condition must be determined at some optimum value of excess air for each furnace installation. Above or below this value, controllable losses increase. A continuous measurement of excess air is then the best criterion of optimum combustion efficiency. In the absence of a known practical method of measuring excess air directly, it was decided to measure the oxygen content of the combustion gases. The relationship of oxygen to excess air for different types of fuel is shown in Fig. 5. The primary advantage of measuring oxy-

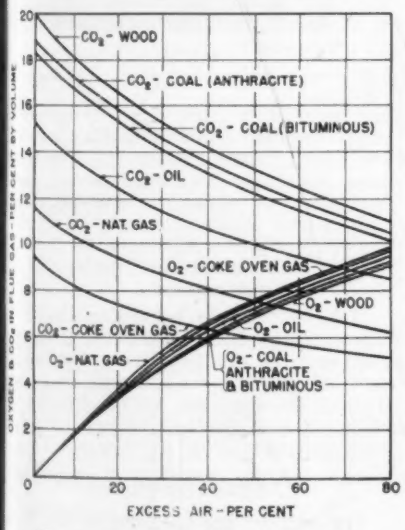

Fig. 5. (Courtesy Bailey Meter Co.)

gen content as an indication of the amount of excess air is that the relationship changes very little regardless of fuel type. The CO_2 content, however, varies considerably for a given amount of excess air and cannot be used to advantage where fuel oil and fuel gas are burned simultaneously.

An oxygen analyzer and a recorder controller were therefore selected. The analyzer operates on the catalytic combustion principle. Measured quantities of combustion gases and a vaporized liquid fuel, both maintained constant by flow regulation, are passed over a catalytic filament. The heat liberated by combustion maintains the filament at a temperature proportional to the oxygen content of the sample. The electrical resistance of the filament is proportional to temperature variations. The filament forms one leg of an A. C. bridge which is continuously balanced by an electronic detector through a motor driven slide wire. This motor also positions the pen on the chart, calibrated directly in percent oxygen, and actuates the control mechanism.

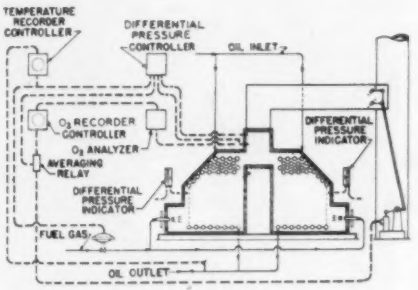

Fig. 6.

The method of connecting the oxygen analyzer and the arrangement of the complete system are shown in Fig. 6. The instrument panel located in the control room with the temperature recorder controller and oxygen recorder controller is reproduced in Fig. 10, while the oxygen analyzer and air flow controller located at the furnace are shown in Fig. 11. It should be mentioned here that, although simplicity is one of our requisites for the combustion control system, it was felt that for this experimental installation all variables which affect combustion efficiency and can be readily measured and automatically controlled without altering basic design of furnace, burners, or fuel systems, should be included in the system.

Operation

A schematic diagram of the complete control circuit with component parts is shown in Fig. 7. The control unit of the temperature recorder is of the conventional pneumatic type with adjustable proportional band. The output loading pressure is transmitted to a standardizing relay, providing proportional speed-floating action. The output pressure from this unit, representing fuel demand, loads the pressure balanced diaphragm control valve in the fuel gas line through a manual automatic selector valve. This same loading pressure is also transmitted to the ratio mechanism of the air flow controller where it is balanced against a differential pressure which represents the measurement of the rate of air flow. The resultant output pressure is connected to one chamber of an averaging relay or totalizer. The other chamber of this relay is loaded by the output pressure of the oxygen recorder controller. The relay output pressure, equal to the sum of these two pressures, is connected through a manual automatic selector valve to the power piston positioning the stack damper. The damper controls the rate of air flow. The control unit of the oxygen recorder has adjustable proportional band action.

To illustrate the sequence of operation, let us assume a state of equilibrium. Heat is being supplied in an amount and at a rate to hold the outlet temperature of the oil at the control point. Also, the rate of air flow is proportioned correctly with fuel flow to maintain the oxygen content of the flue gas at a value selected to give the most efficient combustion.

Furthermore, let us assume that due to a heat load increase the outlet temperature falls below the desired value. With a drop in temperature, the output loading pressure increases a proportionate amount, causing the pressure balanced valve to open until the fuel gas pressure increases to again balance the loading air pressure. (This loading pressure continues to increase, due to the reset action of the standardizing relay, until the temperature returns to the control point.) The higher gas pressure produces a higher differential across the burner orifices thus increasing the fuel gas flow rate.

At the same instant that the gas flow increases, the combustion air flow rate increases in a related amount depending on the ratio adjustment between the loading pressure and differential pressure representing air flow. If the increased fuel and air flow rates are not in the correct ratio to maintain the same combustion efficiency, the resulting change in percent of oxygen in the flue gas will cause an offset from the control point of the oxygen controller. Output loading pressure changes proportionately, increasing with a decrease of oxygen and decreasing with an increase of oxygen. The output pressure from the averaging relay in turn changes an equal amount, repositioning the uptake damper and causing a rate of air flow

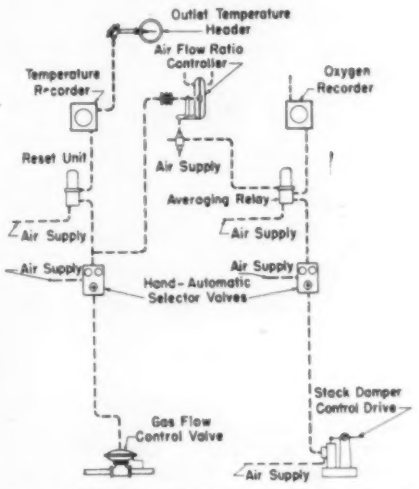

Fig. 7. Schematic Diagram of Control Circuit (Courtesy Bailey Meter Co.)

change in a direction and an amount to return the oxygen content to the desired value.

Results

Very little difficulty was experienced in the initial operations of the system. Once the optimum adjustments of the control units had been established, the system was found to be quite stable and responsive to load changes. Of significance was the short measuring

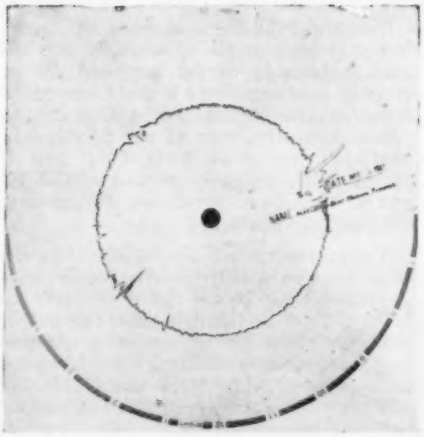

Fig. 8.

time lag of the oxygen control circuit. This permitted operating with a very narrow proportional band adjustment.

As anticipated, a satisfactory ratio adjustment between loading pressure and air flow differential could be established only over very limited load changes because of the non-linear relationships as outlined previously. However, by setting the ratio adjustment to minimize the effect of temperature controller action, the air flow is changed instantaneously with fuel flow change in the right direction by a limited amount. An increment of time later the oxygen controller readjusts the air flow to maintain the desired combustion efficiency. Typical oxygen control records are reproduced in Figs. 8 and 9.

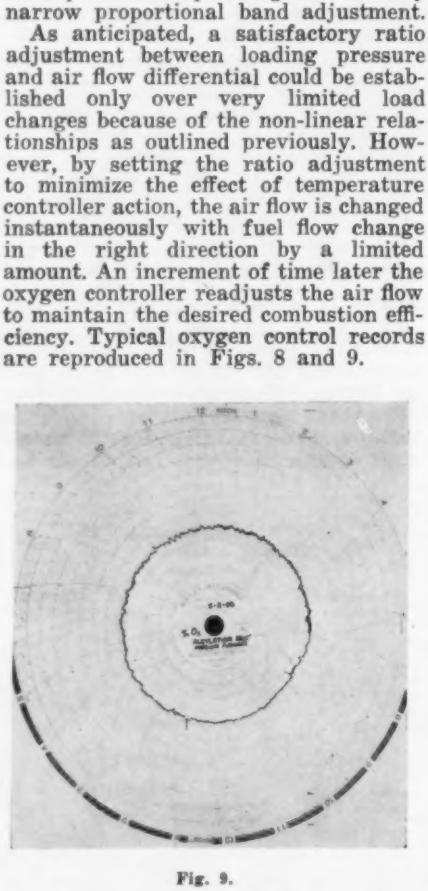

Fig. 9.

In effect then, most of the corrective action for maintaining combustion efficiency is furnished by the oxygen controller. In view of this and the negligible time lag of the oxygen control circuit, the air flow ratio controller was later disconnected from the control system. The averaging relay was reconnected as a standardizing relay furnishing proportional speed-floating action for the oxygen controller. With this arrangement the temperature controller operates only the fuel gas valve, and the oxygen controller operates the stack damper independently. This offers the advantage of simplicity with little if any sacrifice in combustion efficiency. An actual record of oxygen control using this system is reproduced in Fig. 9.

It has been found that further improvement to combustion efficiency is limited only by the design of the burners and furnace combustion chamber. At low loads the control point of the oxygen controller cannot safely be set to a value lower than approximately 8.5% O_2 which corresponds to 64% excess air. Due to excessive air infiltration around the burner ports and other sources, further lowering of the O_2 control point will result in positive fire box pressures. On high loads the oxygen control point is normally set around 4.5% O_2 or 25% excess air. Further lowering of the control point increases fuel consumption for the same heat release, due to unburned gases resulting from inefficient burner mixing. Also, for most efficient operation it is necessary to readjust the burner air port openings manually for widely varying loads. If the burner port opening adjustments, made at low loads, remain the same at high loads, excessive negative furnace pressure results. This is due to the oxygen controller opening the stack damper to increase the air flow and thus increase the pressure drop across the burner ports. As the furnace pressure becomes more negative, air infiltration around the furnace doors and tube supports increases resulting in increased stack losses and also causing the oxygen recorder to indicate an O_2 value above that corresponding to excess combustion air.

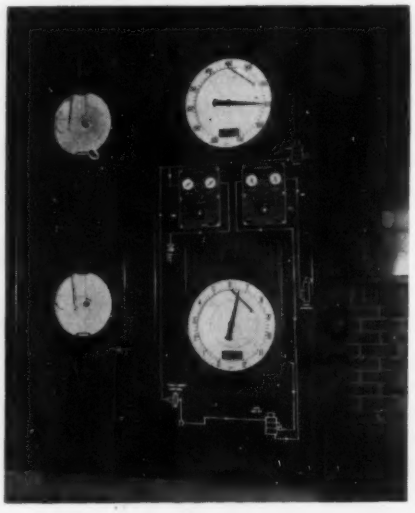

Fig. 10.

Even with these limitations, the improvement in combustion efficiency attributable to the control system represents a reduction of fuel consumption averaging 15%. Based on fuel savings alone the payout time for the complete installation on this furnace was approximately 3½ months.

Conclusion

Aside from the immediate economic benefits and fuel savings resulting from this experimental installation, perhaps of greater significance is the successful demonstration of the oxygen analyzer as a practical instrument for controlling purposes. It offers a comparatively simple method for indirectly recording and controlling excess air or degree of combustion efficiency. After two years of nearly continuous operation, maintenance requirements have been much less than normally expected for the sampling and analyzing type of instrument.

It should again be emphasized here that it is not our intention to recommend a universal combustion control system which can be arbitrarily applied to existing heaters, neither is it intended to imply that the basic principles involved are the ideal nor that the best methods have been used. It does, however, demonstrate that by careful analysis standard control equipment can be applied to many existing furnaces to improve combustion efficiency and materially reduce fuel consumption.

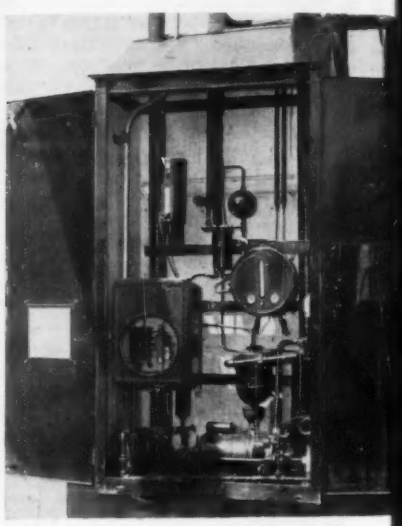

Fig. 11.

It has definitely been established by this experimental installation that further savings of fuel is not limited by lack of suitable measuring and controlling devices, but rather by the inadequacies of present burner and furnace design.

Acknowledgments

The authors are indebted to Mr. P. A. Gibbon, Shell Development Company, for his aid in preparation of this manuscript; Mr. J. G. Kerley, Shell Oil Company, for helpful discussion; The Bailey Meter Company for furnishing certain material and data.

SECTION SECRETARIES AND MEETING DATA

	Telephone	Date	Dinner	Meeting
ron: Fred Appel, 932 Columbia Ct., Barberton, Ohio.		4 Tues.	X	8:00
uba: A. S. MacNutt, c/o Lago Oil & Transport Co., Ltd., Aruba, N.W.I.		1 Tues.	X	7:15
lanta: H. Kockritz, Fischer & Porter Co., 84 Peachtree St., Atlanta, Ga.		4 Mon.	X	7:45
ltimore: Felix Cox, Bethlehem Steel Co., Sparrows Point, Md.		2 Fri.		
ton Rouge: James H. Simpson, 3647 Gladiola, Baton Rouge, La.				
ston: C. J. Nazzaro, 456 Central Avenue, Milton 87, Mass.		Last Wed.	6:00	7:00
lifornia: D. D. Taylor, 234 E. Colorado, Pasadena 1, Calif.		1 Tues.	6:30	
ntral Illinois: H. Frederick Lange, 2101 W. Glen, Peoria, Ill.		1 Wed.	6:30	7:30
ntral Indiana: H. F. Coffey, 110 G Nelson Ave. Tyndall Towne, Indianapolis, Ind.		1 Tues.	X	7:30
arleston: Albert H. Hix, 1529 B Dixie St., Charleston 1. W. Va.		1 Mon.	X	8:00
icago: Floyd E. Ertsman, Rm. 1420 Fisher Bldg., 343 S. Dearborn St., Chicago, Ill.		1 Mon.	6:30	8:00
ncinnati: Smith Hickenlooper, 1147 Beverly Hills Dr., Cincinnati, Ohio.		3 Fri.	X	8:00
veland: R. M. Woodside, Brown Instrument Div. of Minneapolis-Honeywell Reg. Co., 5005 Euclid Ave., Cleveland 5, Ohio.		4 Wed.	6:30	8:00
mberland: Clyde Babst, P. O. Box 447, Cumberland, Md.		*Tues. after 4 Mon.*	6:30	8:00
mit: T. S. Cawthorne, 570 Maccabees Bldg., Detroit 2, Mich.		3 Tues.		
stern New York: Wm. J. Claffie, Winthrop-Stearns, Inc., 33 Riverside Ave., Rensselaer, N. Y.		1 Tues.	6:30	8:00
lf Coast: A. E. Bunn, 2237 North Street, Beaumont, Texas.		3 Tues.		
uston: E. E. Kleir, 2518 S. Blvd., Houston 6, Texas.		Last Mon.	X	8:00
ykern, China Lake, Calif.; A. G. DeBell, U.S. Naval Ordnance, Test Sta., China Lake, Calif.				
nsas City: Lewell F. Spies, J. F. Pritchard & Co., 908 Grand Ave., Kinsas City, Mo.		Last Tues.	6:30	7:30
uisville: H. C. Scherffius, 980 Palatka Rd., Louisville, Ky.		4 Tues.	X	8:00
ntreal: F. S. McCarthy, Canadian Industries, Ltd., Box 10, Montreal, Quebec, Canada.		Last Mon.	X	8:00
w Jersey: W. D. Archibald, 605 Westminster Ave., Elizabeth 3, N. J.		1 Tues.	6:00	
w Orleans: W. H. Haney, 2927 Music Avenue, New Orleans, La.		*No Regular Date*		8:00
w York: Norman J. Cherry, Merrick, L. I., N. Y.		Last Mon.	6:30	8:00
agara Frontier: E. J. Hayter, 374 Huntington Ave., Buffalo, N. Y.		4 Mon.	X	8:00
rth Texas: F. Zapffe, Lone Star Gas Co., 2701 Logan St., Dallas 1, Texas				
rthern Indiana: C. P. Haynes, 935 177th Place, Hammond, Indiana.		3 Wed.	6:30	7:30
k Ridge: John H. Clark, 138 Clayton Hall, Oakridge, Tenn.		1 Wed.	6:30	7:30
tario: John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada.		3 Thur.	6:45	
iladelphia: C. W. Wood, 6908 Market St., Upper Darby, Pa.		3 Wed.	X	8:00
ttsburgh: Miss Louise Suckfield, Gulf Research Corp., Pittsburgh 13, Pa.		4 Mon.	6:30	8:00
squc Isle: Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Penna.		4 Tues.	X	8:00
chland: R. S. Hammond, 402 Abbott, Richland, Washington.		2 Wed.	X	7:30
chester: R. C. Swartz, Jr., 1201 Granite Bldg., Rochester 4, New York.		4 Tues.	X	8:00
Louis: W. G. Lee, 4710 Delor St., St. Louis 16, Mo.		1 Wed.	X	8:00
nia: Mr. Fred T. Yarke, 140 St. Clair St., Point Edward, Ontario, Canada.		2 Fri.	X	
uth Bend: Sam M. Rouse, 436 Moccasin Ave., Buchanan, Mich.		1 Thur.	6:30	7:30
uth Michigan: Homer Kuiper, 2517 Hillsdale, Kalamazoo, Mich.		2 Wed.	6:30	8:00
uth Texas: H. C. Givens, La Gloria Corp., P. O. 637 Falfurrias, Texas.		1 Tues.	X	7:30
nnessee: L. W. Thayer, 1837 Oakwood Dr., Kingsport, Tenn.		*No Definite Night*	7:00	8:00
lsa: C. R. Horton, 8211 E. 7th, Tulsa, Oklahoma.		1 Mon.	X	7:30
in Cities: Ray Hooper, International Div. Minneapolis-Honeywell Reg. Co., 2753 Fourth Ave., Minneapolis 8, Minn.		4 Tues.	6:30	
shington: Edwin G. Brown, c/o American Instrument Co., 8010-20 Georgia Avenue, Silver Spring, Md.		3 Mon.	X	7:30
yne County: R. L. Swenson, 1569 13th St., Wyandotte, Michigan.		3 Mon.	6:30	8:00

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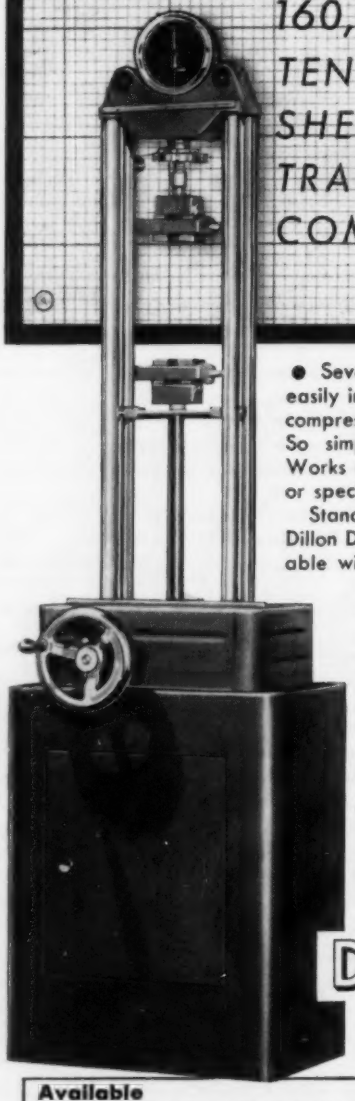

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AIR NAVIGATION PROGRAM INSTRUMENTATIO

Continued from page 493

specific navigation problem involved. All the pilot has to is to keep the vertical needle centered, as he does in flyi to or from an omnirange.

These three units working together—the omnirange, t DME, and the computer—will make off-airway navigati almost as easy and accurate as on-airway flying. And congested airways they will permit operation of multi airways, parallel to each other and a few miles apart, whatever number current traffic demands.

The CAA omnirange installation program is well a vanced. As of April 1, 1949, there were 285 omnirang operable and 47 others in various stages of constructi The interim program calls for about 400 of the new rang some of which will be conversions from an earlier type VHF range.

Several companies now are manufacturing omniran receivers. These are available in models for large transpo type aircraft, and also in low-priced designs for priva pilots. By 1950, the omniranges will be in fairly wide ope tional use; by 1954 they are expected to be the air navig tion standard.

Three DME ground transmitters are now operating, a several others are under construction. Operating models airborne DME equipment are undergoing service testi Both the DME and course line computer are expected reach final development during 1950 and to come into ope tional use soon thereafter.

The SC-31 program calls for VHF communications tween air and ground. All CAA airway and airport facilit have been equipped with transmitters and receivers operati in this static-free radio band, and an increasing amount commercial, military, and private-plane traffic is bei handled over the newer frequencies.

Landing Aids

When the devices mentioned come into general use, trav along our airways obviously will be safer and more reliab But they meet the needs of en route navigation only. Equal important, and more complex, is the problem of getting ai craft down through low ceilings to safe landings—and doi so on a precise, rapid schedule which will permit maximu use of the runways and eliminate the expensive and anno ing "stacks" of planes waiting their turns to land.

Under the SC-31 transition program, radio and rad work together to make bad-weather landings routine a rapid. The fundamental pieces of equipment are the I (Instrument Landing System) which operates on radio pri ciples, and Precision Beam Radar, which uses new techniqu developed during the war. These are supplemented, und the program, by tower surveillance radar, which permi tower traffic controllers to "see" all aircraft in the vicini and by a variety of other devices now in research stages.

Instrument Landing System

ILS uses transmitters located at the airfield to proje two radio beams into space. One beam, called the localiz guides the aircraft laterally to keep it headed toward t centerline of the runway. The other beam, called the gli path, guides the plane's rate of descent and vertical angle approach. ILS gives the pilot something like an invisib highway, down which he can fly by instrument to a sa landing.

The pilot making an ILS approach watches a cross-point indicator in the cockpit. Two needles, one hinged vertical and the other horizontally, cross at right angles when t plane is on the correct approach path. The horizontal nee is actuated by the glide path transmitter on the ground; t vertical needle by the localizer transmitter. By watching t cross-pointer indicator, the pilot can tell when he begins deviate from the proper approach path, and knows how make appropriate corrections.

Vertical-beam radio markers along the approach path i dicate to the pilot how far he has progressed toward the ru

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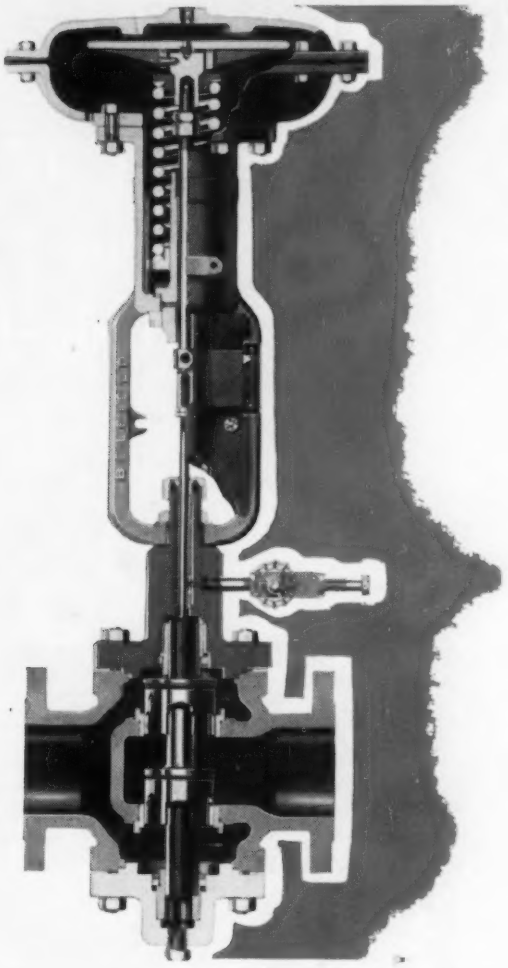

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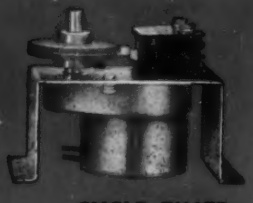

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way. Eventually, the need for these markers will be elim nated by DME.

Precision Beam Radar

Precision beam radar, developed during the war and sin improved, operates on an entirely different principle. He a traffic controller, watching a radar screen on the grou "talks" the pilot down to the runway over ordinary voi radio. The ground controller, guided by the indications the screen, tells the pilot to "fly right," "fly left," "fly up or "fly down," as necessary.

ILS and the precision radar systems each have certa advantages and disadvantages. Used together, they give t pilot a continuous double check on his position, and cons tute the safest and surest landing method known today.

Already, these landing systems have made it possible f the CAA to reduce ceiling minimums to 300 feet at 33 citi and to 200 feet at 34 others. This has brought about mark improvement in schedule regularity at these points. As April 1, there were 87 civilian ILS installations in th country, with another 57 in engineering stages. Civilian pr cision beam radar sets, obtained from military sources, we operating at New York, Washington, and Chicago. Fun are available for 16 other installations, which will becom operable during fiscal years 1950 and 1951.

Surveillance Radar

As mentioned earlier, the only source of information ava able to ground controllers has been position reports fr pilots flying in the vicinity. This is a particularly serio weakness in the vicinity of major airports, where traffic co gestion reaches a peak. The SC-31 interim program calls f surveillance radar equipment in airport traffic control towe so that the controller will have positive information abo nearby aircraft.

Surveillance radar will serve several purposes in additi to the obvious one of reducing collision hazards. The surve lance equipment will be used to guide aircraft to a poi where precision beam radar can pick them up for grou controlled landings. The element of certainty introduced surveillance radar will permit landings in more rapid succe sion than otherwise would be safe, and reduce delays caus by missed approaches. Also important will be reduction delays caused by "lost" aircraft, which sometimes disru traffic in an area for as long as two hours. The CAA is the process of procuring 30 surveillance radars, which w go into service in 1950 and 1951.

Other devices of the transition program are intended mechanize the laborious hand posting system now used control airway traffic, and to secure more efficient use airport runways by means of special calculating equipme Considerable research and development work is necessa before these devices can be put into operation.

Ultimate Program

The SC-31 transition program is intended to meet t current military and civilian needs, and those of the ne five years. Most of the equipment will be integrated into th ultimate program needed to meet long-range future needs.

The ultimate program calls for complete traffic flow co trol, with a reserved landing time for each aircraft before takes off on a flight. It will include visual displays in t cockpit, by means of which pilots can "see" at all times t traffic in their vicinity as well as storms and other hazard

The principles on which the ultimate system will opera are known today. But many of the needed devices have n yet been developed, and intensive research must begin once if the planned schedules for introduction and operati of the equipment are to be met.

Military Urgency

Possibly the weakest link in our whole National Defen chain is the present inadequate air navigation system of t United States. The RTCA program, approved by all branch of the military establishment, has been carefully tailor to meet National Defense as well as civilian needs. A maj reason for selecting the omnirange and DME, for examp lay in its unique adaptability to military needs. A sing omnirange-DME installation, on a beachhead, island, or ne

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Detects humidity changes as small as plus-minus 0.15% relative humidity.

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Responds instantly to micro changes in relative humidity at temperatures from 40° to 140° F. Response is slightly slower below 40° F., whereas other types are unresponsive.

MOST ACCURATE

Measures accurately within plus-minus 1½% relative humidity, without periodic attention.

OCCUPIES LESS SPACE

Sensing element occupies a maximum of two cubic inches.

MOST RELIABLE

Guaranteed for one year. Will give many more years of satisfactory service when used properly.

MOST VERSATILE

1. Can be used to measure, indicate, record and/or control relative humidity, also to drive air-operated devices.

2. Can be used for remote control operation, since long connecting lines may be employed.

3. Since it does not add or remove moisture or heat, it can be built into hermetically-sealed electrical components.

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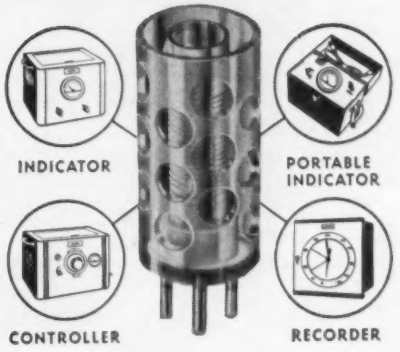
5. Measures moisture content of solids as well as of air and other non-corrosive gases.



This tiny element (illustrated actual size) is used in conjunction with one or more of the instruments shown in circles above for obtaining various combinations for measuring, recording, and controlling relative humidity.

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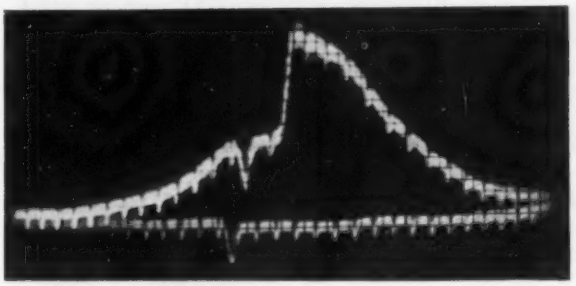

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a fighting front, meets the navigational requirements for all planes in that area.

The radar and communication chains of the common system will be integrated into the military early-warning network. The common system equipment is not designed to take the place of military radar, but to supplement it in case of emergency.

The increasing military use of jet aircraft has introduced a serious complication into air traffic control. A conventional airliner carries substantial fuel reserves and can, if necessary, hold near an airport for long periods of time awaiting its turn to land. Jet planes have no such fuel reserve; unless they can be assured of an immediate landing they must operate far below their normal ranges.

The answer to this problem lies in traffic flow control which assures a "reserved" landing time for each aircraft before it leaves the ground. The transition program will meet the immediate needs of jet aircraft in this respect, and the ultimate system will provide complete flow control.

Without the common transition system and common ultimate program of air navigation, the Air Force and MATS obviously would have to install an airway system of their own to meet their National Defense obligations. Such a system would duplicate expenditures necessary for civil aviation, and would offer the taxpayer no prospect of monetary return.

By increasing our peacetime civil air operations, with consequent expansion of our civil fleet, we will gain in preparedness at comparatively little direct cost to the taxpayer. To whatever extent the common air navigation system stimulates civil aviation, to that extent the burden of meeting minimum military cargo needs is shifted from the taxpayer to private industry.

Were civil air transportation able to grow to a reasonable portion of its apparent potential size, annual production of civil transports could possibly double or triple the current output, thus adding to the peacetime level from which the manufacturing industry could expand in an emergency. The increased fleet would, in itself, be of considerable militar importance. But what would be vitally valuable would be a healthy aircraft manufacturing industry in being, supported to a significantly lesser extent by the U. S. taxpayer.

Production of military aircraft reached a peak of 96,31 in 1944. But it required four years to build up the momentum necessary to reach the 1944 pace, and production was stimulated as early as 1940 by large foreign orders.

Few experts today believe that in case of another war we will have any such extended time to bring our aircraft production lines into high gear. And there may be no time at all to install a needed new air navigation system and train men in its use.

Civil Aviation's Need

Why do pullman cars carry twice as much passenger traffic as the airlines? Why do railroad coaches and bus lines combined carry eight times as much passenger traffic? Three major answers are:

1. Aviation has the lowest schedule reliability of any type of common carrier.
2. Despite tremendous gains in recent years, the aviation safety record is far below that of other common carriers.
3. Travel by air is more expensive than by other carriers.

The RTCA common air navigation program is designed to help overcome all three chief handicaps of civil aviation. The transition program is expected to contribute substantially toward this goal.

Air Passenger Traffic.—Lack of schedule reliability is one of the biggest stumbling-blocks to the growth of civil aviation. After a generation of steady growth, the scheduled airlines appear to have reached a ceiling in passenger traffic through which they cannot climb. There is no reason to believe that we have reached any inherent economic ceiling to air passenger business, for every new type of transportation has created entirely new and broader travel markets.

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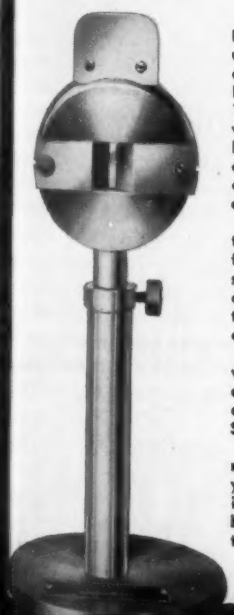

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*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

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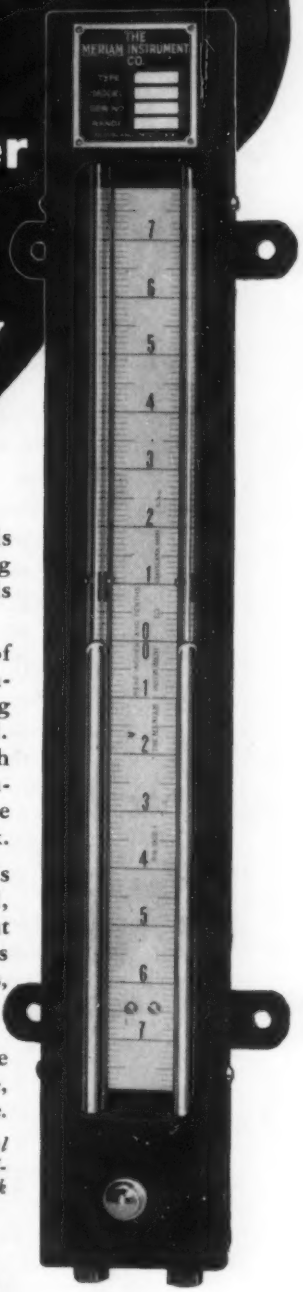

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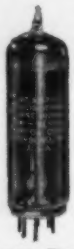

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uncertainty has prevented our airlines from substantially developing this otherwise-untouched travel field. A person who must be at a specific place at a definite time hesitates to gamble on the vagaries of weather and air traffic congestion. As often as not, he simply decides not to make the trip at all. The airlines can do little about this situation without an improved airway system.

Another factor in civil aviation's present plight is safety. No one can estimate how many potential air passengers shun air travel because they or their families fear its hazards. Aviation accidents attract wide attention from the press and radio. This may have exaggerated the degree of risk in the public mind. Few people are aware that the National Safety Council has produced figures for the period of 1945 through 1947 which show that an airline passenger was slightly safer than a passenger in a private automobile or taxi. On the other hand, the same source shows that a passenger was 11 times as safe on a bus as aboard an airliner covering the same distance, and a train passenger was 13 times as safe.

Schedule irregularities tend to increase during winter months and drop to a minimum in summer. The result is an extreme seasonal swing in airline business. The range of seasonal variation for trunk-airline passenger-miles is about 56 percent (as against about 24 percent for pullman travel). This wide seasonal swing costs the airlines millions of dollars annually, and has been an important factor in forcing them to higher fares.

The CAA has completed an interesting study of the possible effects of the RTCA transition program in reducing seasonal variations and thereby improving the airline financial picture. The study assumes that, as a result of year-round regularity and safety provided by the transition system, the seasonal variation will decline to a point halfway between the combined pullman-plus-airline figure and the airline figure.

Had the seasonal swing leveled even to this degree in 1948, the study indicates, airline deficit before mail pay might have been reduced by $20,000,000. With the same mail pay, the airlines might have broken even in fiscal 1948 instead of facing a deficit of $20,702,000.

The study then assumes that the improved regularity and safety, in addition to reducing seasonal variation, brings about a one-third increase in passenger traffic, reduced fares, and much-increased cargo business. In this event, the scheduled airlines might reasonably expect an annual net taxable income of $30,300,000 in place of current deficits.

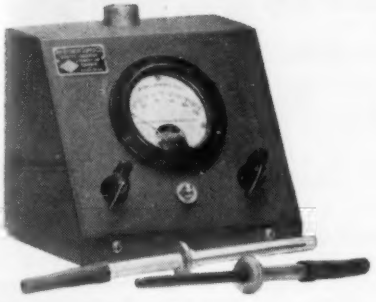
Air Cargo.—Lack of reliability today is eliminating much of the economic value of air cargo to the vast majority of its potential market. Our current domestic air cargo amounts to but 150 million ton-miles per year. The annual domestic air cargo potential is estimated to be 500 million ton-miles at present rates of 18 to 20 cents a ton-mile. If the rate were to drop to 14 or 15 cents, the estimated potential is 1.2 billion ton-miles; at 9 to 10 cents, it is 3 billion ton-miles.

Even with its present limitations, air cargo has revolutionized the distribution and warehousing systems and inventory methods in readymade dresses, shoes, and parts of the electrical equipment industry. It has so extended the cut flower market that the southern grower can sell in the northern markets more cheaply than the local grower in the north. It has made air transportation of some agricultural products common trade practice.

Air Mail.—If reliability of air mail delivery were improved, the Post Office Department believes that much additional mail would be generated. This increased volume would reduce unit postal costs of ground handling and overhead. At the same time, not all air mail carriers, domestic and international, can carry more mail without additional mail pay accruing to them. Furthermore, there are numerous sliding scale mail rates, which decline as passenger load factors rise. It is apparent that the RTCA program will play an important part in reducing and eventually eliminating these air mail deficits.

Feeder Lines.—The disproportion between air mail to

SMOKE METER



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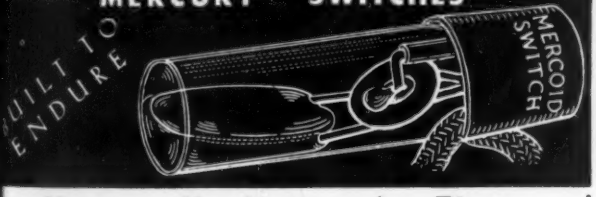

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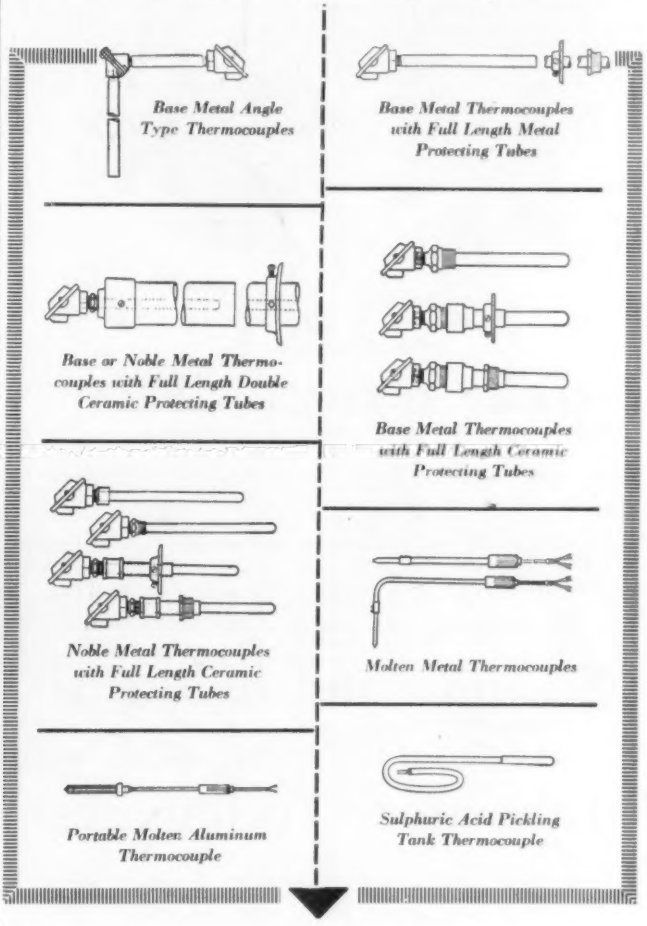
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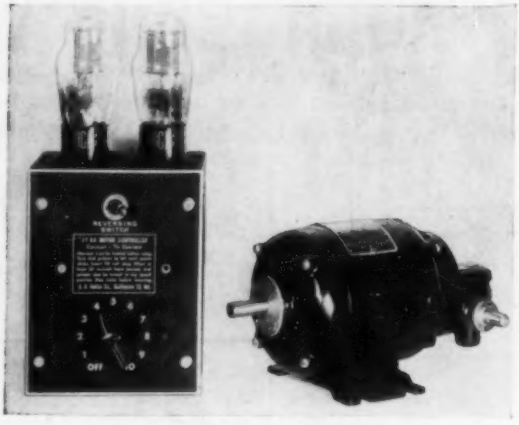

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nage actually carried and air mail payments make the ef of the RTCA program on feeder airlines particularly portant from the standpoint of Post Office air mail defic Air mail subsidy payments can be reduced to whate degree the smaller lines become financially independent self-sufficient.

The potential volume of short-haul passenger busi is huge. Bus and railroad coach travel, averaging 50 to miles per passenger, together generate about 50 bil passenger-miles annually. Automobile trips of 100 miles more generate an additional 60 billion passenger-miles nually. Total airline passenger traffic is six billion passeng miles annually.

Existing feeder lines have thus far been able to deve an annual passenger-mile rate of only about 100 mill The chief reason seems to be that short-distance travel are even more influenced than long-distance travelers by need of schedule reliability. To a man making a trip two hundred miles, a two- or three-hour delay makes advantages of air travel seem negligible. Yet today o half of all domestic airline passengers average but miles per trip.

Overseas Operations.—The importance of our inter tional airlines to national defense and national prestige obvious. That is the chief justification for these carri receiving substantial annual mail payments for a rat meager total of mail ton-miles. The RTCA program facilit by reducing operating costs and improving the competit position of our international airlines, will make a dir dollar return in reduced air mail subsidies, international well as domestic.

Personal Aircraft.—Sales of small planes have drop off sharply in the past two years. This potentially-import segment of our economy shows signs of stagnation. A gr ing number of people believe that the natural expansion private flying is being stifled by lack of utility in our pres types of small aircraft. The basic elements of the RT system, such as the omnirange, precision beam radar, VHF communication, are readily adaptable to personal-t aircraft at modest cost to the owners. By increasing usefulness of present and future types of small planes, RTCA program will stimulate the use of such planes personal and business transportation.

Manufacturing.—The military need of a stable and p gressive aircraft manufacturing industry, supported larg by civil aviation, is urgent. Equally important, howev are the peace-time benefits which will flow to our natio economy from a growing, financially-healthy manufact ing industry.

The RTCA program will stimulate all phases of airl operations through public acceptance of the airplane a reliable and safe method of transportation. This stimu will be passed on to the large-plane manufacturing fi resulting in a natural expansion through normal econo channels, with a constantly decreasing burden on the t payer.

Airports.—Taxpayers have an investment of about and one-half billion dollars in civil airports. Of the lar airports, only a handful are self-supporting even to extent of returning out-of-pocket operating and maintena expenses. The RTCA program can make most of these t supported airports into good investments by substanti increasing the volume of air traffic, and also by provid airport income during bad-weather as well as good-weat periods.

Time Saving.—Still another benefit, intangible but v important, will accrue to our economy from reliable c aviation. When civil aviation is able to provide fast reliable service in the volume of which it is inherer capable, the saving to our citizens in productive time al should total many tens of thousands of valuable m years annually.

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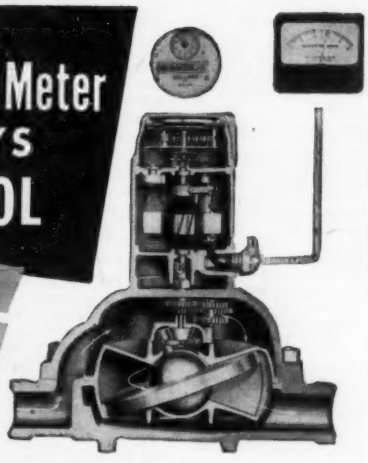

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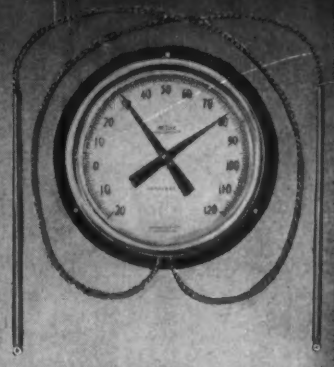

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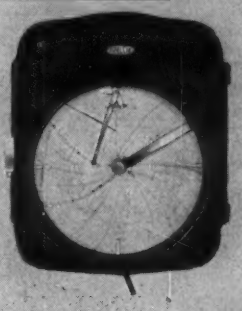

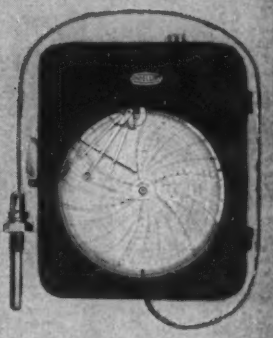

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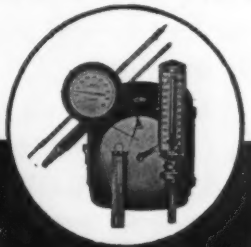

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from manufacturers. We urge readers to request ONLY those bulletins which will be of value them. Use the Postage-free Order Card on Page 547.

R-274 SELENIUM RECTIFIERS. 24-page Catalog VC-3000 describes and illustrates maker's selenium rectifiers. Discusses characteristics, applications, design factors, etc.—Vickers Electric Div., Vickers Inc., 1815 Locust St., St. Louis, Mo.

R-275 PHOTOELECTRIC CELLS. 12-page Catalog VC-4000 describes and illustrates maker's self-generating photoelectric cell applications and design specifications. — Vickers Electric Div., Vickers Inc., 1815 Locust St., St. Louis, Mo.

R-276 AIR FILTER AND DEHYDRATOR. Description sheet and two illustration sheets announce new "Condensifilter" especially designed for instrument air service. Unit dehydrates air, removes all droplets and finally filters air. The Hankinson Corp., 1501 Beaver Ave., Pittsburgh 12, Penna.

R-277 PROFILE MEASURING MICROSCOPE. 8-page bulletin describes maker's profile measuring microscope for applications such as checking core diameters, pitch, angle of inclination, form of thread, etc. Technical data, general working outline, accessories, are listed.—Hauser Machine Tool Corp., Manhassett, N. Y.

R-278 CONDENSATE DRAINAGE CONTROL. 24-page Publication No. 3250 describes maker's system of condensate drainage control for increasing production and improving quality with steam processing equipment. Contains data on steam flow conditions, heat exchange characteristics, etc.—Cochrane Corp., 17th Street and Allegheny Ave., Philadelphia 32, Penna.

R-279 ANALYTICAL INSTRUMENTS. 16-page Catalog CEC-1300A (general catalog 1948-1949) is divided into two sections: mass spectrometry and static-dynamic measuring and recording; presents in brief form complete line of precision instruments designed and manufactured by maker.—Consolidated Engineering Corp., 620 North Lake Ave., Pasadena, Calif.

R-280 TELEVISION COMPONENTS. 32-page Booklet CTV-1004 provides technical data including characteristics and dimensional outlines for 18 RCA television components for use in receiver designs using new 16 in. metal-cone picture tube. Also contains circuit data.—Radio Corp. of America, RCA Victor Div., Harrison, N. J.

R-281 THERMOSTATIC CONTROL VALVES. 6-page Bulletin C-3 describes and illustrates various types of maker's control valves, including: temperature regulators, mixing valves, etc. Construction, design, sizes, etc., are listed.—Lawler Automatic Controls, Inc., 453 No. MacQuesten Parkway, Mt. Vernon, N. Y.

R-282 TIME SWITCHES. 8-page Bulletin No. 249 describes and illustrates maker's devices for turning electrical circuits on and off regularly. Available in many capacities for indoor and outdoor use.—Tork Clock Co., Inc., 1 Grove St., Mt. Vernon, N. Y.

R-283 PRECISION TIMERS. 8-page bulletin describes and illustrates maker's stop watches, chronographs, and other precision timers, for laboratory, industrial and sports uses.—Clebar Watch Co., 551 Fifth Ave., New York 17, N. Y.

R-284 DUCTILITY TESTING EQUIPMENT. 12-page Bulletin No. 39 covers maker's complete line of ductility testing equipment, including hand-operated, motor-driven, and automatic testing machines. Also includes list of tools and installation instructions for machines.—Tinius Olsen Testing Machine Co., 1116 Easton Road, Willow Grove, Penna.

R-285 ELECTRIC CIRCUIT CONTROLLER. 4-page Bulletin 503 describes and illustrates maker's "Regohm," a universal electric circuit controller of the direct-acting finger type. Ratings, dimensions, application information, etc., included.—Electric Regulator Corp., 1938 Park Ave., New York 35, N. Y.

R-286 "THE CAPACITOR." 16-page Vol. 14, No. 4 issue of this house organ presents article titled "Simple Methods of Measuring Inductance of Air-core and Powdered-Iron-Core Coils." Included is "The Radio Trading Post," a section for buyers, sellers and swappers. — Cornell-Dubi Electric Corp., Hamilton Blvd., South Plainf N. J.

R-287 SOLDERLESS TERMINALS. 4-p bulletin describes and illustrates maker's solde wire terminals, including: pre-insulated, wire, splicing, and other terminals. Also descri are hand tools and plan for purchasers of te nals to borrow special wire terminator with cost.—Aircraft-Marine Products, Inc., 1523 N 4th Street, Harrisburg, Penna.

R-288 REGULATED D-C. POWER SUPP 2-page bulletin describes and illustrates mak "B-Nobatron" regulated d-c. power supply, ing electrical characteristics, mechanical speci tions, appearance, etc.—Sorenson and Co., I 375 Fairfield Ave., Stamford, Conn.

R-289 WEIGHING SYSTEMS. 56-page bo let describes and illustrates maker's hydraulic pneumatic weighing system components. Inclu are: Bourdon indicators, commercial record tubing and hose lines, hydraulic jacks, etc.—A. Emery Co., Stamford, Conn.

R290 HYDRAULIC CRANE SCALES. 4-p bulletin describes and illustrates maker's "EU T," "EU-40-T," and "EU-60-T," hydraulic c scales with respective capacities of 10,000, 20, and 30,000 lbs. Features, prices, etc., are discus —A. H. Emery Co., Stamford, Conn.

R-291 "FLUORESCENCE TEST FOR URA UM IN ACQUEOUS SOLUTION." 8-page ar describes a method for qualitative detection uranium, based on yellow-green fluorescence o phosphate solution under influence of short-w ultraviolet light.—Bureau of Mines, Metallurg Branch, Salt Lake City, Utah.

R-292 DIAPHRAGM SEALS. 10-page fo contains sheets which illustrate and describe var models of maker's diaphragm seals. Stock sh diagrams, and work sheet for ordering informa are included.—Mansfield & Green, 1051 Po Ave., Cleveland 14, Ohio.

R-293 "THE OHMITE NEWS." 2-page i of this house organ presents discussion titled " sign of Field Rheostats for Self-Excited Gen tors." Included is "Unusual Items" section; of maker's products.—Ohmite Mfg. Co., 4835 Flourney St., Chicago 44, Ill.

R-294 SOLDERING GUNS. 2-page bull describes and pictures maker's soldering which feature: five-second heating, prefoc spotlight, built-in transformer, trigger switch, Models, their primary uses, prices, etc., are li —Weller Mfg. Co., Easton, Penna.

R-295 "THE FUELOMIZER." 16-page Vol No. 2 issue of this house organ presents ar titled "Varying 'Soot' Compositions Affect Bo Efficiency," and other articles of interest to t in the field.—Jno. D. Hiles Co., Inc., Plaza Bl Pittsburgh, Penna.

R-296 AIRCRAFT PRODUCTS. 4-page b tin describes and illustrates maker's tube coupli fuel valves, hydraulic valves, flareless coupli underwing fuel valves, and lubricants. — Pa Appliance Co., Cleveland 12, Ohio.

R-297 "THE MAINSPRING." Spring No. Coil No. 12 issue of this house organ pres article titled "What Goes On In a Spring Du Presetting?"—Associated Spring Corp., Bri Conn.

R-298 HERMETICALLY SEALED RELAYS page circular describes and illustrates mak "Automatic Electric Sealed Relays" which sealed in a metal container enclosing an atmosp of dry, inert gas. Sealing process, applications, are discussed.—Automatic Electric Sales Co 1033 W. Van Buren St., Chicago 7, Ill.

R-299 RADIOACTIVITY MEASUREME 36-page Catalog J is announced as "a comp new catalog of instrumentation for radioact measurement." It describes and illustrates: scaling units, (2) counting systems, (3) monito instruments, (4) detectors, (5) accessories. It g applications, manufacturing methods, etc.

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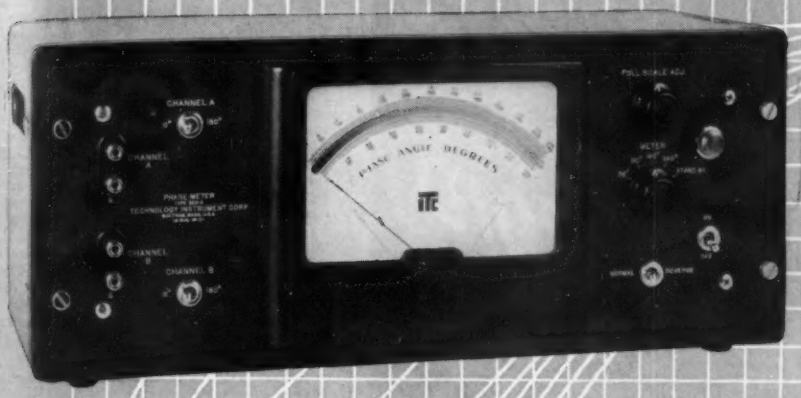

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R-300 COUNTER AND CONTROL INSER ER. 2-page Bulletin 309-A describes and illustra maker's counter and control inserters for placi paper markers automatically at any preset co up to 4000 sheets between markers. "Model C portable model, and "Model C-1" fixed model discussed.—Counter and Control Corp., 2757 28th St., Milwaukee, Wisconsin.

R-301 RECORDING COUNTERS. 4-page b letin describes and illustrates maker's records counter said to have wide application in indus and science. Counter prints on paper tape; can actuated by any electrical pulse or signal from contact switch, phototube and amplifier, etc. Us features, etc., are discussed.—Streeter Amet C 4101 N. Ravenswood Ave., Chicago 13, Ill.

R-302 STEAM AND LIQUID CONTRO EQUIPMENT. 62-page Catalog No. 49 describ and illustrates maker's steam and liquid cont equipment including pressure regulators, temp ature regulators, float valves, steam traps, etc. I cludes dimensions, applications, capacities, etc O. C. Keckley Co., 400 West Madison St., Chi cago 6, Ill.

R-303 TESTING MACHINE ACCESSORIE 12-page Bulletin No. 261-A describes and illu trates the supplementary devices used to ada testing machines to widest scope of testing con tions. Included are: cold bending fixtures, lo weighing air cells, etc.—Baldwin Locomotiv Works, Philadelphia 42, Penna.

R-304 MICRO HARDNESS TESTER. 4-pa Bulletin K-49 describes and illustrates maker "Kentron" micro hardness tester for individu particulars, inclusions, etc. Features, design, co struction, etc., are discussed.—Kent Cliff Labo tories, Peekskill, N. Y.

R-305 FINE-PITCH GEARS. 6-page catal presents detailed data on maker's line of 48, and 96 pitch brass spur gears.—Instrument Ge Works, 2815 Irving Park Road, Chicago 18, Ill.

R-306 RESISTORS. 2-page technical data bu letin describes and illustrates maker's "Type BW one-half, one, and two-watt insulated wire-wou resistors. Features, characteristics, etc., are liste —International Resistance Co., 401 N. Broad St Philadelphia, Penna.

R-307 MERCURY RELAYS. 4-page bulleti describes and illustrates maker's mercury plung relays, listing features, characteristics, etc.—Ebe Engineering & Mfg. Co., 185-09 Jamaica Ave Hollis 7, Long Island, N. Y.

R-308 FILM APPLICATOR. 6-page folder d scribes and illustrates maker's film applicator f producing uniform films preparatory to testing lists features, applications, operating instructions etc.—Henry A. Gardner Laboratory, Inc., 47 Elm St., Bethesda 14, Md.

R-309 LOAD MEASURING BEAMS. 2-pa Bulletin No. 274 describes and illustrates maker "SR-4" load beams such as for process and ma chine control; general force measurement. Rang and dimensions, applications, etc., are discussed. Baldwin Locomotive Works, Philadelphia 4 Penna.

R-310 CATHODE-RAY OSCILLOGRAPH. page bulletin describes and illustrates maker "Model 505A" cathode-ray oscillograph, said t be ideally suited for television. Also describ "Model 195B" general purpose 5-in. oscillograp Features, characteristics, etc., are discussed. Hickok Electrical Instrument Co., 10514 Dupo Ave., Cleveland 8, Ohio.

R-311 "USES UNLIMITED." 2-page Vol. No. 2 issue of this house organ contains discu sion of maker's "Micro Sealed Switches," "Micr Latch Connectors," and beryllium copper switche —Microswitch, Freeport, Ill.

R-312 CHECK VALVES. 2-page bulletin d scribes and illustrates maker's "Twin Seal" che valve suitable for water, air, oil, gas; any medi not destructive to rubber or synthetic rubber. Mansfield & Green, 4601 Euclid Ave., Cleveland Ohio.

R-313 "HYDRAULIC CIRCUIT ANALYSIS. 8-page Bulletin No. 112 presents article titl "Hydraulic Circuit Analysis." Lists maker's lite ature available on products.—Parker Applianc Co., Cleveland 12, Ohio.

R-314 FUEL SELECTOR VALVES. 16-pa Bulletin No. 521 describes and illustrates vario models of maker's "Pressure Balanced" aircra fuel selector valves; manually operated, or wi "Bendix Geneva-Loc Actuator." Features, speci cations, etc., are listed.—Parker Appliance Co Cleveland 12, Ohio.

R-315 PORTABLE ULTRASONIC INSTRU MENT. 4-page Bulletin No. 3700 describes an illustrates maker's "Reflectogage" for visual ind cations of thickness of metals and other material from one side of material only. General operati instructions, principle of operation, specificatio etc., are listed.—Sperry Products, Inc., Danbur Conn.

R-316 SENSITIVE ALTIMETERS. 4-page Pu lication No. T.P. 24A describes and illustra

maker's type "FA-112" and "FA-185" sensitive altimeters to obtain vertical control for aerial surveys, topographic mapping, gravity meter surveys, etc. Features, operation, construction, etc., are discussed.—Wallace & Tiernan Products, Inc., Belleville 9, New Jersey.

R-317 "CEC RECORDINGS." 6-page Vol. 2, No. 2 June issue of this house organ presents discussions titled: "Galvanometer Design Undergoes Startling Change in 10-Year Period." "New Applications for Leak Detector Found in Diverse Industries," and other articles.—Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif.

R-318 PRECISION METAL PARTS. 12-page bulletin describes and illustrates maker's precision machine parts, small metal stampings, screw machine parts, formed wire parts, etc. Burner and burner parts are also described; facilities and personnel are discussed.—Haydu Brothers, Plainfield, N. J.

R-319 "TAYLOR TECHNOLOGY." 28-page Vol. 1, No. 4 issue of this house organ features articles titled: "Manufacture of Streptomycin," "The New Transaire Temperature Transmitter," "World's Largest Belt Press," and others —Taylor Instrument Companies, Rochester 1, N. Y.

R-320 "THE ARCO SNAP." 4-page Vol. 1, No. 8 issue of this house organ contains items of general interest, and special discussions for those within the organization.—Arco Switch Co., 1305 Superior Ave., Cleveland 14, Ohio.

R-321 PYROMETERS. 4-page bulletin describes and illustrates maker's "Symplytrol" indicating and controlling pyrometer, a thermocouple type control for furnaces, ovens, kilns etc. Ranges and prices for various other types of pyrometers are listed.—Assembly Products, Inc., Chagrin Falls, Ohio.

R-322 CARBON MONOXIDE TESTER. 2-page Bulletin No. BY-1 describes and pictures maker's "Colorimetric" carbon monoxide tester which is said to meet requirements of public utilities, industrial hygienists, mine inspectors, etc.; wherever accurate determination of low toxic concentrations of CO is desirable.—Mine Safety Appliance Co., Braddock, Thomas and Meade Streets, Pittsburgh 8, Pa.

R-323 DEMAND RECORDERS. 2-page Bulletin 452 describes and pictures maker's Graphic Demand Meter types "CCWF" and "CCAF" for watt demand measurement. Meters are designed for flush mounting. Dimension diagrams are included.—Sangamo Electric Co., Springfield, Ill.

R-324 DUST SAMPLERS. 4-page bulletin describes and illustrates maker's "Midget" impinger which samples dust at rate of one-tenth cubic foot per min.; is hand cranked. Also listed is all-glass "Midget" impinger units, dust counting microscopes, dust counting cells.—Mine Safety Appliances Co., Braddock, Thomas and Meade Streets, Pittsburgh 8, Pa.

R-325 GEIGER-MULLER SCALER. 4-page bulletin describes and illustrates maker's "Model 1000-B" improved portable scaler for all nuclear measurements, medical work, industrial applications, physical and chemical research. Advantages, characteristics, accessories, are listed.— Berkeley Scientific Co., 601 Nevin Ave., Richmond, Calif.

R-326 LABORATORY SUPPLIES. Catalog 49 is an 8-inch by 11-inch cloth-bound book of 700 pages, presenting thorough data on instruments, accessories, etc. Will be sent free of charge to responsible persons in companies and institutions making requests on their letterheads. To all others, the price is ten dollars, which will be applied as

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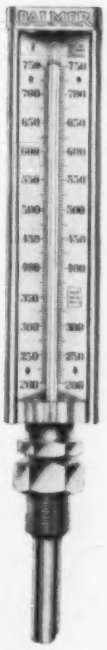

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R-327 AMPERE DEMAND METERS. 2-page Bulletin 462 pictures and describes maker's "Type AD-2" ampere demand meter for flush mounting, supplied in 3, 5, or 6 amp. full-scale rating. Dimension diagrams are included.—Sangamo Electric Co., Springfield, Ill.

R-328 CHROMIC ACID SAMPLER. 2-page Bulletin No. CT-8 describes and illustrates maker's "Samplair" for quantitatively estimating the concentration of chromic mist in the air. Gives applications, features, and list of users such as safety engineers, public health authorities, shop foremen, etc.—Mine Safety Appliances Co., Braddock, Thomas and Meade Streets, Pittsburgh 8, Pa.

R-329 MICROSCOPES. 2-page bulletin describes and illustrates maker's "Model F" professional microscope. Special features and construction are discussed.—Testa Mfg. Co., 418 South Pecan St., Los Angeles 33, Calif.

R-330 DISCHARGE TYPE CAPACITOR. 2-page bulletin describes and illustrates maker's "Type AVL-3204" heavy-duty discharge type capacitor, listing capacity and voltage rating, dimensions, features, uses, etc.—Cornell-Dubilier, South Plainfield, N. J.

R-331 CARBON DETERMINATOR. 2-page bulletin describes and illustrates maker's "Leco No. 4000" semi-automatic carbon determinator. Listed are advantages, features, models, etc.—Laboratory Equipment Corp., St. Joseph, Mich.

R-332 COMBUSTION BOATS. 2-page bulletin pictures and describes maker's "Leco HF Series" combustion boats for gravimetric carbon analysis. Sizes, prices, etc., are listed.—Laboratory Equipment Corp., St. Joseph, Mich.

R-333 MICROTOME KNIFE SHARPENERS. 4-page bulletin pictures and describes maker's microtome motor-driven knife sharpener, listing special advantages, operations, specifications, etc. —Berkeley Scientific Co., Sixth and Nevin Ave., Richmond, Calif.

R-334 "A PRIMER OF ELECTRONICS." 4-page booklet presents a simple introduction to the electron and the principles that govern its use.—General Electric Co., Schenectady 5, N. Y.

R-335 "APPLICATIONS OF ATOMIC POWER." 26-page booklet contains six addresses by staff members of G. E. Research Laboratory given on the 1945 Science Forum Program of Station WGY, Schenectady, N. Y.—General Electric Co., Schenectady 5, N. Y.

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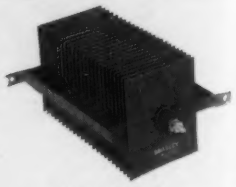

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